



Outeniqua Research Farm

Information Day 2026

Presented by: Research and
Technology Development Services



Western Cape
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FOR YOU

Agriculture

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OUTENIQUA RESEARCH FARM INFORMATION DAY 2026



VENUE OFF FARM



28 October '26



**NG Kerk
Moedergemeente
George Hall**

PROGRAMME

08:30	Registration	
09:30	Opening & Welcoming	Dr Filicity Vries
09:40	Hybrid ryegrass production potential and summer persistence	Sigrun Ammann
10:00	Pasture renovation: a game of hit and miss....	Janke van der Colf
10:20	Chicory and plantain: yield, forage quality and disease resistance	Sigrun Ammann
10:40	Effect of diatoms on milk production	Bertus Myburgh

11:00

TEA BREAK

11:30	Grazing type red clovers: first year cultivar evaluation results in a grass sward	Sigrun Ammann
11:50	Nutrient losses from pastoral systems	Dr Henk Smit
12:10	Pasture measurement: work smarter not harder	Janke van der Colf
12:30	Robocop on Outeniqua: embracing technology in pasture research	Dalena Lombard
12:45	Facilitated discussion	Dr Filicity Vries
13:00	Concluding remarks	TBC

13:10

LUNCH



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PREFACE

As I write my first preface for the Outeniqua Information Day 2026 as Chief Director: Research and Technology Development Services, I do so with a deep sense of responsibility and gratitude. I follow Dr Trautmann, who served the Department for more than two decades, and I am committed to building on the strong foundation that has been laid.

The year 2026 highlighted both the resilience and vulnerability of the agricultural sector. Farmers across the province continued to navigate an increasingly complex operating environment characterised by climate variability, market pressures, rising input costs, biosecurity risks, and growing expectations for sustainable production. Of particular significance was the outbreak of Foot-and-Mouth Disease (FMD), which posed substantial challenges for the livestock industry and required coordinated responses from government, industry bodies, research institutions, and producers. The associated restrictions affected livestock movement, agricultural events, research activities, and industry operations, underscoring the importance of effective disease surveillance, biosecurity, rapid response capabilities, and science-based decision-making.

As the sector continues to evolve, the Department remains committed to supporting our farmers, helping them to increase production and lower input costs. Research will play an increasingly important role in this regard, driving innovation, climate resilience, disease preparedness, resource efficiency, and sustainable agricultural growth.

This year, the well-known Outeniqua Information Day is again presented by a dedicated pasture and dairy research team. They are not only experts in their respective fields, but who also understand the researcher-farmer interface very well.

Thank you for your partnership with Outeniqua and its research team. I trust you will find today informative, insightful and enjoyable, and I wish you a productive and successful Information Day.

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HYBRID RYEGRASS PRODUCTION POTENTIAL AND SUMMER PERSISTENCE

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Introduction

Hybrid ryegrass (*Lolium x hybridum*) is a cross between Italian and perennial ryegrass. The resulting cultivars are then either Italian-type hybrids or perennial-type hybrids. Some cultivars could be termed intermediate. Figure 1 shows where hybrid ryegrass types fit into the ryegrass continuum.

Hybrid ryegrass cultivars have the ability to produce vegetative tillers after flowering which results in the increased persistence. The perennial-type hybrids have the potential for longer persistence than the Italian type

hybrids. Creating hybrid ryegrasses aims to combine the fast establishment and early growth, especially winter, of Italian ryegrass with the longer persistence of perennial ryegrass into the second year. Hybrid ryegrass generally has a lower flowering incidence, especially the perennial type hybrids than Italian ryegrass does due to the dual induction requirements where a certain number of cold days are required followed by increasing daylength as shown in Figure 2. The perennial-type hybrids generally have a lower flowering incidence than the Italian-type hybrids, which then also translates into better forage quality in terms of lower fibre content.

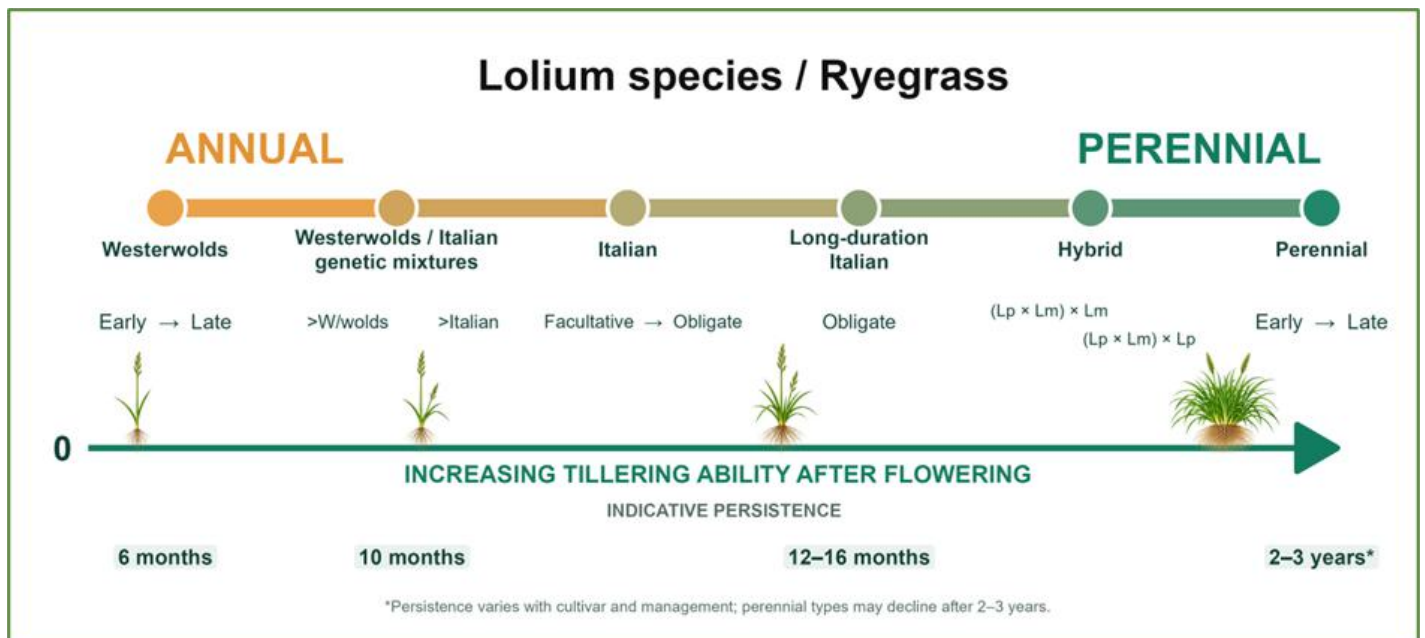


Figure 1. Hybrid ryegrass types in the ryegrass continuum are located between long-duration Italian and perennial ryegrass types.

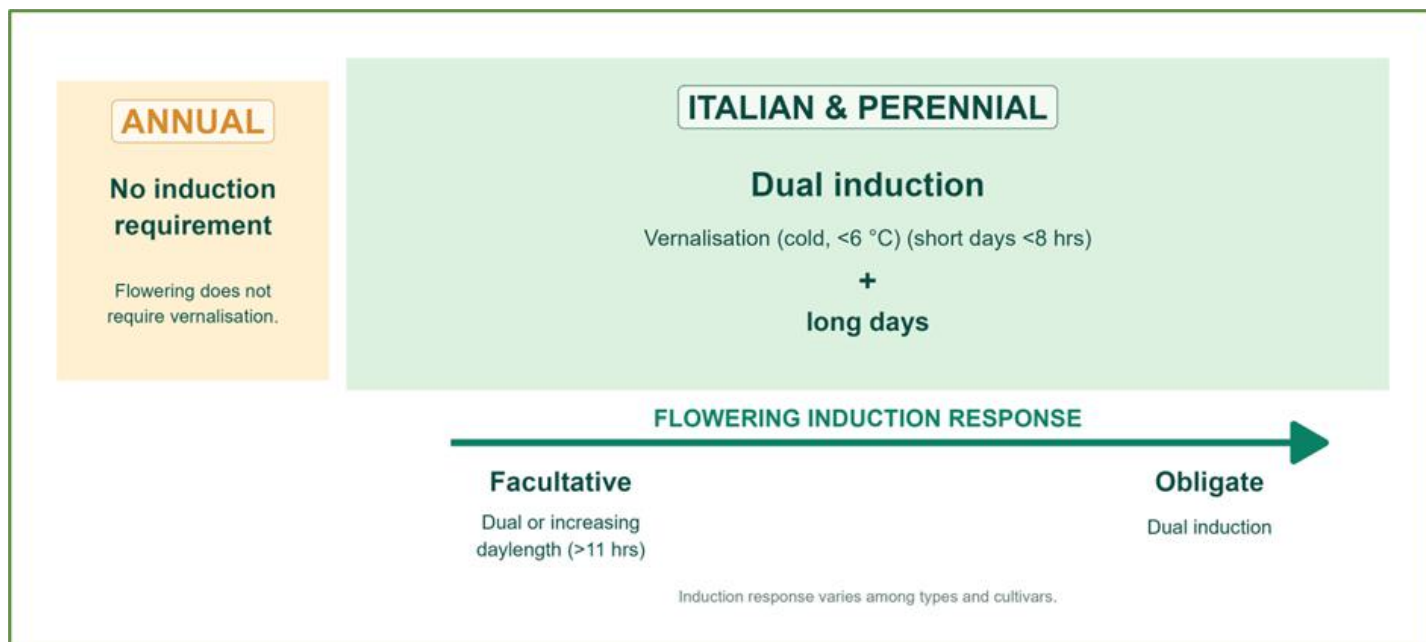


Figure 2. Induction requirements for flowering of different ryegrass types.

System-fit

In terms of system fit, hybrid ryegrasses are suited to mixtures with components that last longer than one year. For mixed pastures that last several years, the Italian-type hybrid ryegrass can be oversown towards the end of the mixed pasture cycle to boost the productivity before the mixed pasture is completely renewed or reset. The perennial-type hybrids can be used earlier in the mixed-pasture cycle since they will persist for longer than the Italian-type hybrids. The option of having a ryegrass type with fast growth like Italian types and but more reliable persistence into summer and the second autumn, makes hybrid ryegrass an attractive option amongst ryegrass types, including if it means flowering incidence is lower than Italian ryegrass types.

Hybrid ryegrass evaluation

The hybrid ryegrass trial Lh1, which was established in March 2025 at the Outeniqua Research Farm is the first trial specifically dedicated to testing hybrid ryegrass cultivars. In the past the Italian-type hybrids were included in the Italian ryegrass trial while the perennial-type hybrids were included in the perennial ryegrass trial. While that approach also provides valuable information, the increased popularity of hybrid ryegrass cultivars and the need in terms of system fit with the extended growth duration particularly in mixed pastures, warranted a trial dedicated to the species on its own and evaluating the spectrum of cultivars available to farmers in South Africa. The trial contains both diploid and tetraploid varieties, although more tetraploid varieties were submitted than diploid. In Europe the tetraploid cultivars are favoured since they tend to yield better (Nay et al 2022). However, in

South Africa it is very cultivar specific since the growth conditions are often less than optimal for ryegrass resulting in other genetic characteristics playing a role for yield over and above the ploidy.

There is one ryegrass-type *Festulolium* in the trial which is commonly marketed in the dairy pasture industry for more difficult environments. As controls, there are a tetraploid perennial ryegrass and an Italian ryegrass cultivar. There is one so-called Westerwolds-type hybrid cultivar which is however mainly used as a niche product outside of the dairy industry, as indicated by the company selling it.

Endophyte containing cultivars

An additional factor investigated in this trial is endophyte-containing cultivars. These consist of two perennial-type hybrids and one Italian-type hybrid, namely Legion, Platform and Mohaka respectively. Each cultivar has a low or no-endophyte version versus one containing a novel-endophyte.

Easton (1999) and Easton et al (2001) give extensive insight into endophytes in ryegrass. Endophytes naturally infect ryegrass plants especially perennial ryegrass and hybrid ryegrass due to perennial ryegrass being part of the genetic make-up. The endophyte symbiosis is especially relevant in New Zealand but does to a lesser extent occur in other parts of the world as well. The standard endophyte produces various alkaloid metabolites which protect the plant but also cause ryegrass staggers in cattle (Easton 1999). The main alkaloid responsible to staggers is lolitrem B. The alkaloid ergovaline also occurs in the standard endophyte and is responsible for heat stress in cattle (Easton 1999). The third alkaloid is peramine. This does not

affect animals negatively but also protects the plant, as reported by Easton 1999 and Easton et al 2001. In New Zealand research over many years has developed so-called novel endophytes which do not cause animal health issues (Dairy NZ, www.dairynz.co.nz/feed/pasture-species/endophytes). These are endophyte strains that have been selected to protect the plant while not causing animal health problems.

The endophyte strains contained in the three hybrid ryegrass cultivars in this trial are AR1 and AR37. According to Dairy NZ, both AR1 and AR37 originate from France. AR1 produces only peramine and provides protection against Argentinean stem weevil and pasture mealy bug. It only provides weak protection against African Black beetle and no protection against root aphids, porina and grass grub (Dairy NZ, www.dairynz.co.nz/feed/pasture-species/endophytes). AR37 on the other hand, according to Dairy NZ, contain other compounds called janthitrems rather than peramine, which give the plant a wide range of protection. In the 2026 report on endophytes by the New Zealand Plant Breeding and Research Association (PBRA 2026), AR37 provides protection against Argentine stem weevil, African black beetle, root aphids, pasture mealy bug and porina.

Whether endophyte containing ryegrass is required in South Africa will largely depend on identifying specific insect pressures in ryegrass pastures and evaluating cultivars with novel endophyte in the research trials. It requires comparisons between ones that do not contain these novel endophytes or at least not at the required levels to effect insect control to those that do and establishing whether it is leading to improved persistence and production. To complicate the evaluation, insect pressure in pastures would also vary depending on the prevailing conditions in a particular year. This will mean that cultivars with novel endophytes will have to be evaluated over a suitable period to determine effectiveness together with identifying insect pests in the pasture trials.

The New Zealand Plant Breeding and Research Association provides guidelines on how best to ensure sufficient levels of viable endophyte in seed with a threshold of 70% set as the minimum standard for effective pest control

(Endophyte summary, seed storage & sowing | NZPBRA). Seed management is very important in this regard. According to Easton et al (2001), long-term storage conditions for survival of endophyte in the seed must be below 5°C with not more than 50% relative humidity and seed moisture at 11%. This is currently the challenge for selling endophyte containing seed in South Africa since it needs to be imported and generally does not survive the shipping journey and still be above the 70% threshold. There are however new strains of endophyte constantly under development. According to Agricom NZ (per comm) this includes better survival at higher temperatures and will make the transportation to other continents more feasible.

Ryegrass is an important component of dairy pasture production. However, persistence and resilience to conditions during the summer months is challenging. Hence important aspects of the evaluation process, over and above yield and especially the yield potential in the warmer months, are persistence, rust resistance and low flowering incidence. Due to the milder minimum temperatures in winter, vernalization is often limited and for some cultivars the requirements for flowering are only partially met. This has the advantage that the forage quality is better maintained due to lower flowering incidence, however the NDF values may nonetheless be higher in the summer months than expected from ryegrass when conditions are limiting for optimal growth. Ideally all ryegrass should also be utilized in multi-species swards to add a level of resilience especially for the summer months.

The overall aim of the cultivar evaluation trials at Outeniqua Research Farm is to provide local, unbiased data to assist farmers in their choice of cultivars best adapted to the coastal region. The trials provide insight into the genetic potential and adaptation specifically for the Southern Cape region, but with wider applicability to the coastal dairy production regions.

Cultivars evaluated

The trial, Lh1, consists of 22 cultivars as indicated in the tables below:

Hybrid Italian Diploid cultivars	Barando, Barhill
Hybrid Italian Tetraploid cultivars	Astoncrusader, Barmada, Bastille, Boxer, Frenzy, Greenmount (LhM1904), Mohaka AR1, Mohaka AR37, Mohaka LE, Palliser, Shogun
Hybrid Perennial Diploid cultivars	Legion AR37, Legion LE, Platform, Platform AR37
Hybrid perennial Tetraploid cultivars	Forge
Festulolium ryegrass type	Rockstar
Westerwolds Intermediate	Bandito 2
Italian ryegrass control tetraploid	Barmutra II
Perennial ryegrass control tetraploid	Base

Types in trial Lh1	No. of cultivars	Ploidy	
		Diploid	Tetraploid
Hybrid Italian type	13	2	11
Hybrid Perennial type	5	4	1
Festulolium – ryegrass type	1	-	1
Westerwolds Intermediate type	1	-	1
Italian ryegrass control	1	-	1
Perennial ryegrass control	1	-	1

Parameters reported in this article

- Total DM yield
- Seasonal DM yield
- Flowering behaviour
- Persistence / sward density
- Disease incidence (mainly crown rust)

Trial design and management

The trial is designed as a Randomised Block Design with three replications. Gross plot size is 2.1m x 6m and net plot size is 1.3m x 4.7m. Diploids are sown at a rate of 25kg/ha and tetraploids at 30kg/ha, with rows spaced 15cm apart. The trial is harvested according to physiological stage based on 3-leaf for ryegrass. In spring canopy closure is considered before leaf stage to avoid a negative impact on daughter tiller development. Since leaf emergence rate is mainly driven by temperature, as well as radiation intensity, water and nutrient availability (Chapman 2016), most cultivars reach the 3-leaf stage at a similar time.

Plots are cut with a reciprocating mower (Agria) at 5cm height. The material from the net plot is sampled for dry matter determination with an approximately 500g wet weight sample and the rest of the material is raked together and weighed. Samples are weighed and oven dried at 70°C.

The trial is top-dressed with nitrogen fertilizer after each harvest, and potassium fertilizer to account for nutrient removal, since all material is removed from the trial.

Irrigation was applied weekly if necessary to add to the

rainfall and after fertilization. Due to drought conditions from May 2025 through to Beginning of May 2026, the irrigation water measured an increasingly high EC level implying increased salinity levels. Towards the end of summer the plants showed visual signs of stress which could in part be ascribed to the high EC levels in the irrigation water.

Results

Total yield (Table 1) is always one of the most important criteria. The establishment and input costs are similar regardless of yield, hence the importance of choosing the cultivars with the best yield to get a better return on the establishment and input costs, being mainly fertilizer and irrigation. The data for total yield is given as both Year 1 and the 15-month total. The first year from March 2025 to February 2026 includes the establishment period in March (Figure 3). The trial was planted on 19 March 2025. The 15-month total includes the second autumn (autumn 2026 March to May) (Figure 4). The persistence through summer and into the second autumn has a significant effect on the total yield and is also what farmers are looking for if they plant a hybrid ryegrass. The hypothesis is that hybrid ryegrass cultivars persist and yield better through summer and into autumn than Italian ryegrass and that this characteristic is also more predictable than it is in Italian ryegrass cultivars. There are Italian ryegrass cultivars that do persist through summer into the second autumn but the consistency thereof can be low i.e. in some years the long-duration Italian ryegrass cultivars will persist through summer and the second autumn while in other years not so. This is where the hybrid ryegrass cultivars are hypothesised to be more consistent. That will only become evident after several years of trials.

Table 1. Seasonal yield of hybrid ryegrass

			Hybrid ryegrass (<i>Lolium x.hybridum</i>)						Outeniqua Research Farm, Trial Lh1							
			Table 1: Seasonal yield (t DM/ha)						Planted 19 March 2025							
Cultivars	Species	Plaidy	Autumn 2025	Rank	Winter 2025	Rank	Spring 2025	Rank	Summer 2025/26	Rank	Autumn 2026	Rank	Total Year 1	Rank	Total 15 months	Rank
Astoncrusader	Hy II-type	T	2,06 ^{ghi}	20	2,11 ⁱ	22	3,98 ^{cdef}	13	1,14 ^h	20	0,83 ^m	21	9,28 ^e	21	10,11 ^f	21
Barando	Hy II-type	D	2,67 ^a	2	3,35 ^{ab}	3	4,00 ^{cdef}	12	2,73 ^{cdef}	15	2,05 ^{efgh}	10	12,75 ^{ab}	6	14,80 ^{ab}	7
Barhill	Hy II-type	D	2,46 ^{abcdef}	10	2,59 ^{defgh}	17	4,47 ^{abcd}	6	2,80 ^{cde}	14	2,05 ^{efgh}	9	12,32 ^{bcd}	11	14,37 ^{bcd}	10
Barmada	Hy II-type	T	2,51 ^{abcde}	8	2,48 ^{efgh}	18	4,60 ^{abc}	4	3,28 ^{abc}	4	2,31 ^{cde}	5	12,87 ^{ab}	2	15,19 ^{ab}	4
Barmultra II	Italian	T	2,71 ^a	1	2,79 ^{bcdefg}	14	4,65 ^{ab}	3	1,09 ^h	21	1,13 ^{lm}	20	11,24 ^{cd}	18	12,37 ^e	20
Base	Perennial	T	2,26 ^{cdefg}	13	3,15 ^{abcd}	8	3,87 ^{def}	16	3,28 ^{abc}	3	2,63 ^{abc}	3	12,57 ^{ab}	8	15,20 ^{ab}	3
Bastille	Hy II-type	T	2,59 ^{abc}	4	2,32 ^{ghi}	20	4,89 ^a	1	2,85 ^{bode}	12	2,31 ^{cde}	6	12,66 ^{ab}	7	14,97 ^{ab}	6
Boxer	Hy II-type	T	2,18 ^{defghi}	16	2,60 ^{cdefgh}	16	4,58 ^{abc}	5	1,93 ^q	19	1,29 ^{kl}	19	11,30 ^{cd}	16	12,59 ^e	19
Forge	Hy PR-type	T	2,49 ^{abcde}	9	3,54 ^a	1	4,65 ^{ab}	2	2,16 ^{fg}	18	1,76 ^{hij}	15	12,86 ^{ab}	3	14,62 ^{bc}	8
Frenzy	Hy II-type	T	2,30 ^{bcdefg}	12	3,34 ^{ab}	5	4,39 ^{abcde}	8	2,83 ^{bode}	13	1,49 ^{kl}	18	12,85 ^{ab}	4	14,34 ^{bcd}	11
Legion AR37	Hy PR-type	D	2,18 ^{defghi}	15	3,12 ^{abcd}	9	3,80 ^{ef}	19	3,23 ^{abcd}	5	2,75 ^{ab}	2	12,33 ^{bcd}	10	15,08 ^{ab}	5
Legion LE	Hy PR-type	D	2,11 ^{fghi}	19	3,19 ^{abcd}	7	3,78 ^{ef}	20	2,95 ^{bode}	8	2,19 ^{defg}	8	12,02 ^{bcd}	15	14,21 ^{bcd}	13
LhM1904*	Hy II-type	T	2,53 ^{abcd}	6	3,34 ^{ab}	4	4,19 ^{bcdef}	11	3,62 ^a	1	2,47 ^{bcd}	4	13,69 ^a	1	16,16 ^a	1
Mohaka AR1	Hy II-type	T	2,43 ^{abcdef}	11	2,39 ^{fgh}	19	4,26 ^{bcdef}	9	3,09 ^{abcde}	7	2,02 ^{efgh}	11	12,17 ^{bcd}	14	14,19 ^{bcd}	14
Mohaka AR37	Hy II-type	T	2,55 ^{abcd}	5	3,05 ^{abcde}	11	3,94 ^{def}	14	2,92 ^{bode}	10	1,83 ^{ghij}	14	12,46 ^{abc}	9	14,29 ^{bcd}	12
Mohaka LE	Hy II-type	T	2,12 ^{fghi}	18	2,61 ^{cdefgh}	15	3,84 ^{def}	18	2,67 ^{def}	16	1,49 ^{kl}	17	11,24 ^{cd}	17	12,73 ^e	18
Palliser	Hy II-type	T	2,15 ^{efghi}	17	2,98 ^{abcdef}	12	3,90 ^{def}	15	3,23 ^{abcd}	6	1,87 ^{fghij}	13	12,26 ^{bcd}	12	14,12 ^{bcd}	15
Platform	Hy PR-type	D	1,87 ⁱ	22	2,84 ^{bcdefg}	13	3,64 ^f	21	2,87 ^{bode}	11	1,89 ^{fghi}	12	11,21 ^{cd}	19	13,11 ^{de}	17
Platform AR37	Hy PR-type	D	1,88 ^{hi}	21	3,08 ^{abcde}	10	3,86 ^{def}	17	3,40 ^{ab}	2	3,01 ^a	1	12,21 ^{bcd}	13	15,22 ^{ab}	2
Rockstar	FL Lolium-type	T	2,24 ^{cdefgh}	14	1,74 ⁱ	22	4,22 ^{bcdef}	10	2,95 ^{bode}	9	2,25 ^{def}	7	11,14 ^d	20	13,39 ^{cde}	16
Shogun	Hy II-type	T	2,52 ^{abcde}	7	3,22 ^{abc}	6	4,47 ^{abcd}	7	2,60 ^{ef}	17	1,60 ^{jk}	16	12,80 ^{ab}	5	14,40 ^{bcd}	9
Bandito 2	Ww-II-type	T	2,66 ^{ab}	3	3,40 ^{ab}	2	2,15 ^q	22	0,11 ⁱ	22	0	22	8,31 ^e	22	8,31 ^q	22
LSD (0.05)			0,37		0,63		0,63		0,59		0,39		1,26		1,39	
CV%			9,62		13,3		9,37		13,6		12,5		6,41		6,10	
Yields with the same letter are statistically similar within a column																
Hv: Hybrid ryegrass; II: Italian ryegrass; PR: perennial ryegrass; FL: Festulolium; Ww: Westeroids																

Yields with the same letter are statistically similar within a column

Hy: Hybrid ryegrass; IT: Italian ryegrass; PR: perennial ryegrass; FL: Festulolium; Ww: Westeroids

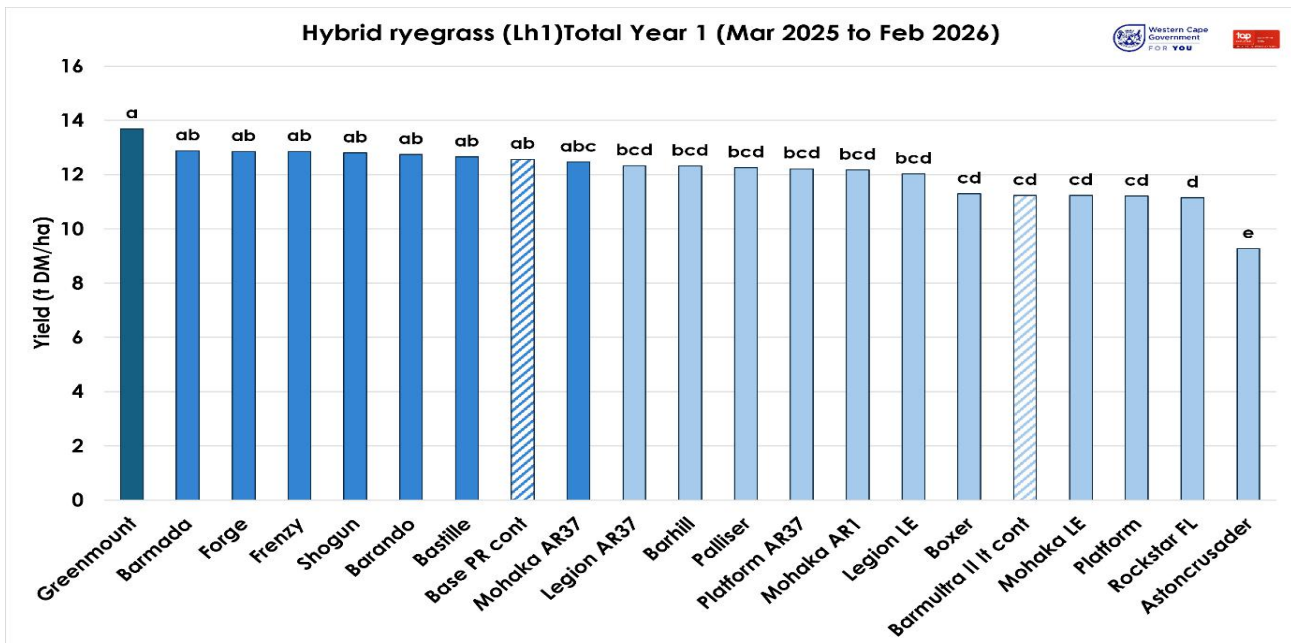


Figure 3. Total yield (t DM/ha) for year one for hybrid ryegrass cultivars compared with a perennial ryegrass control (cv. Base PR cont) and an Italian ryegrass control (cv. Barmultra II It cont). Yields with the same letter are similar ($p < 0.05$).

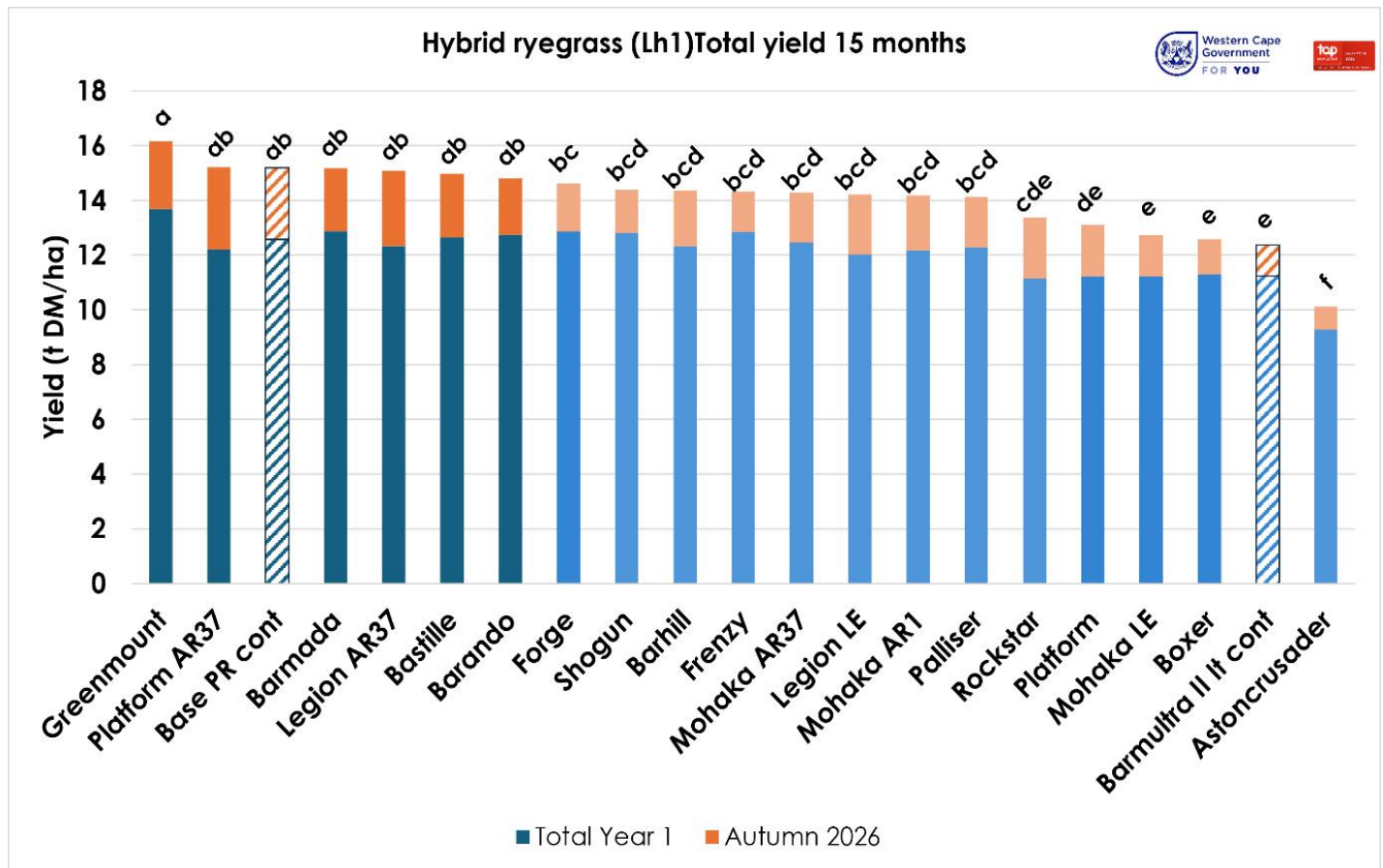


Figure 4. Total yield (t DM/ha) of hybrid ryegrass cultivars (trial Lh1) for the first 15 months of the trial consisting of five seasons including the second autumn. The controls are perennial ryegrass cv. Base (PR cont) and Italian ryegrass cultivar Barmultra II (It cont). Yields with the same letter are similar ($p < 0.05$).

Seasonal yield data (Table 1) is of value for optimising fodder flow requirements especially for the more challenging seasons which are generally winter and summer/beginning of autumn. The question is whether there are cultivars with both good winter and summer yield. Alternatively, it is advisable to plant fields to different cultivars to take advantage of different seasonal yield distribution patterns and to spread risk or plant a combination of cultivars. Incorporating other species like forage herbs or legumes in a mixed sward with the ryegrass can be used to boost summer production, for instance. As an example, a high yielding spring cultivar can be considered for silage making of the surplus production. Mixed swards do improve the resilience of the pasture overall.

For hybrid ryegrass cultivars it is important to assess their

value according to their summer and second autumn yield, as this is the main advantage over Italian ryegrass cultivars. The other advantage of hybrid ryegrass over perennial ryegrass would be the faster establishment in autumn, hence the yield in the first autumn, which is the establishment season. In Figure 5 it shows that most of the Italian-type hybrid cultivars are comparable to the Italian control in the establishment season, being the first autumn. They are also superior to the perennial ryegrass control in the first autumn.

Winter yield is an important criterion. This should be considered in the context of total yield. Figure 6 shows the top group for winter with the highlighted cultivars in the top group for yield over 15 months.

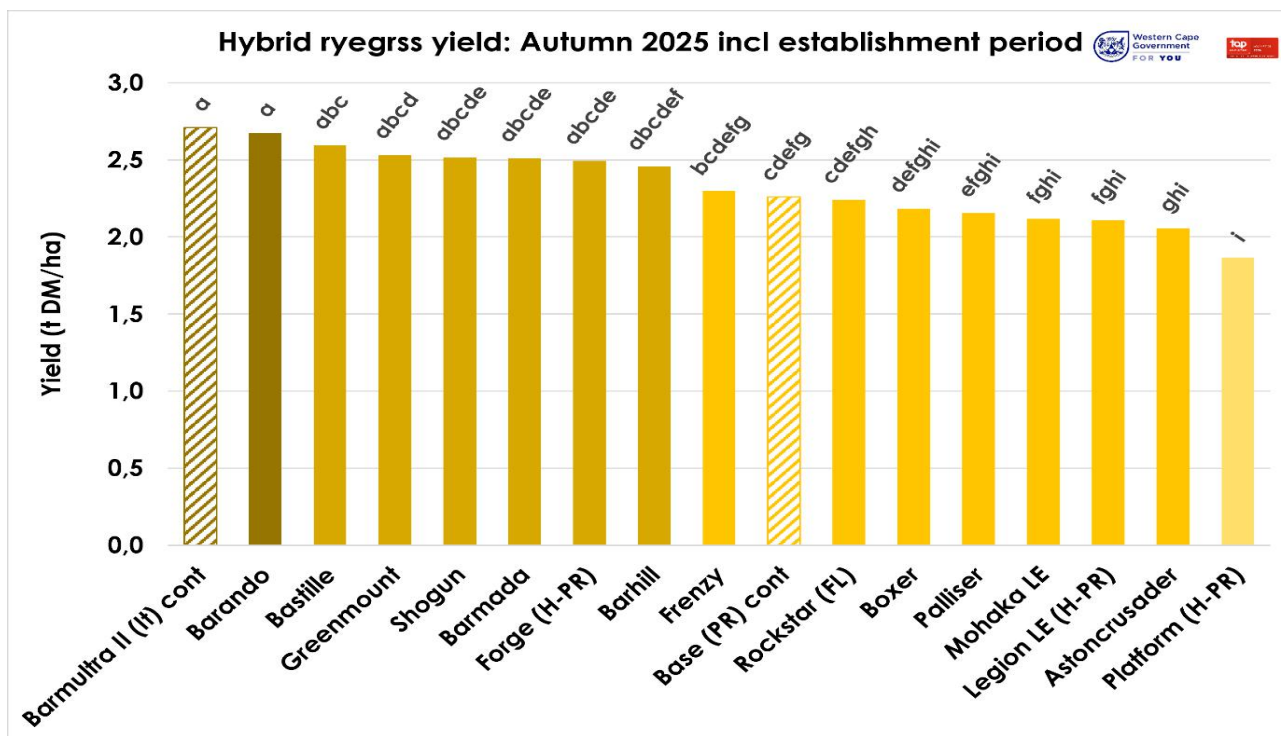


Figure 5. Dry matter yield (trial Lh1) for the first autumn (t DM/ha) including the establishment period. The controls are perennial ryegrass cv. Base (PR cont) and Italian ryegrass cultivar Barmultra II (It cont). Yields with the same letter are similar ($p < 0.05$).

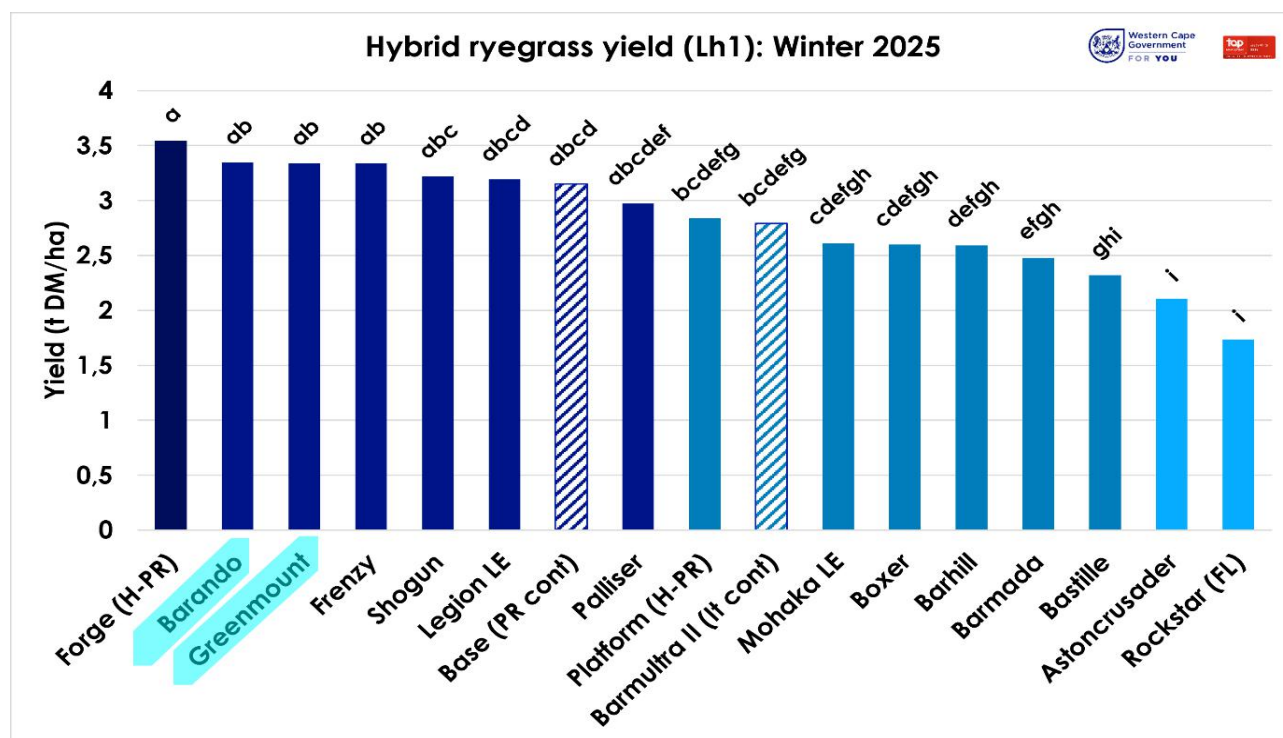


Figure 6. Dry matter yield for the first winter (t DM/ha) for trial Lh1. Cultivar names highlighted are ones that are in the top group for Yield over 15 months. Yields with the same letter are similar ($p < 0.05$).

Summer and the second autumn are the most important seasons regarding hybrid ryegrass since these are the season that should show an improvement over Italian ryegrass. It should be noted that in certain years with favourable weather conditions, Italian ryegrass cultivars

that are of the obligate, long-duration type may perform similar to hybrid ryegrass cultivars. One would expect hybrid ryegrasses to be more consistent for persistence in the warmer months. Figure 7 and Figure 8 show the warm season dry matter yields.

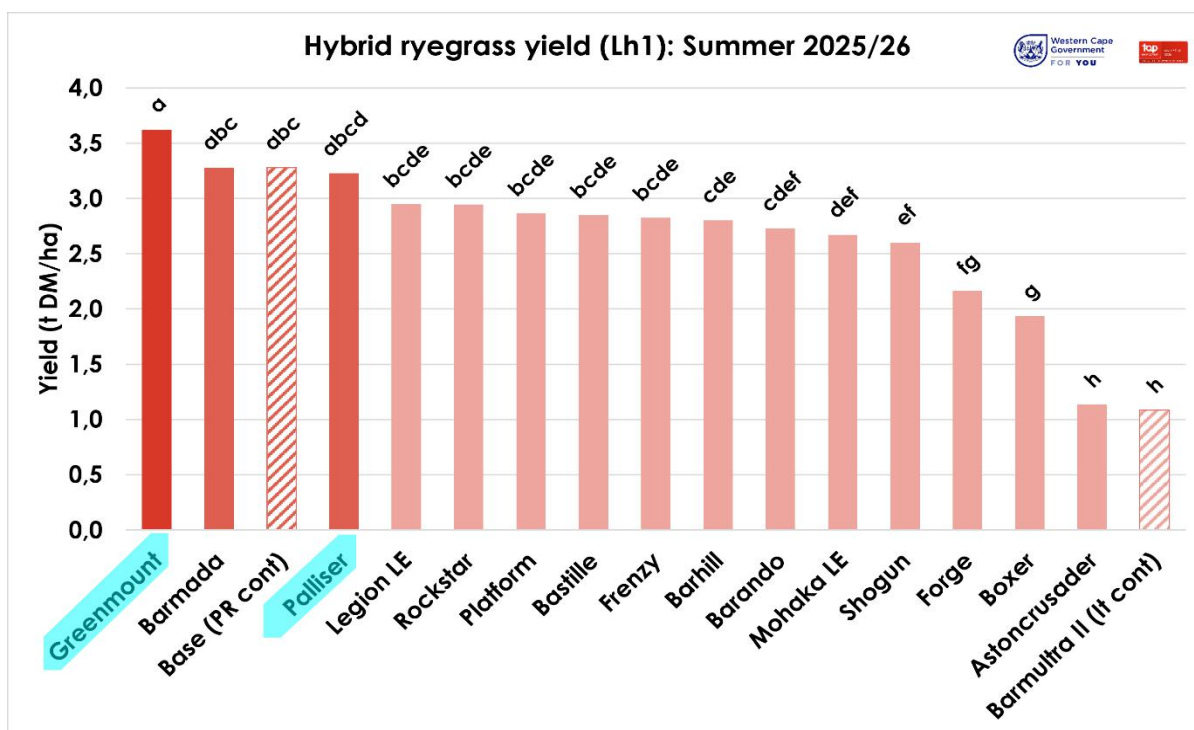


Figure 7. Dry matter yield (t DM/ha) for the first summer 2025/26 (December to February) for trial Lh1. Cultivar names highlighted are ones that are in the top group for yield over 15 months. Yields with the same letter are similar ($p < 0.05$).

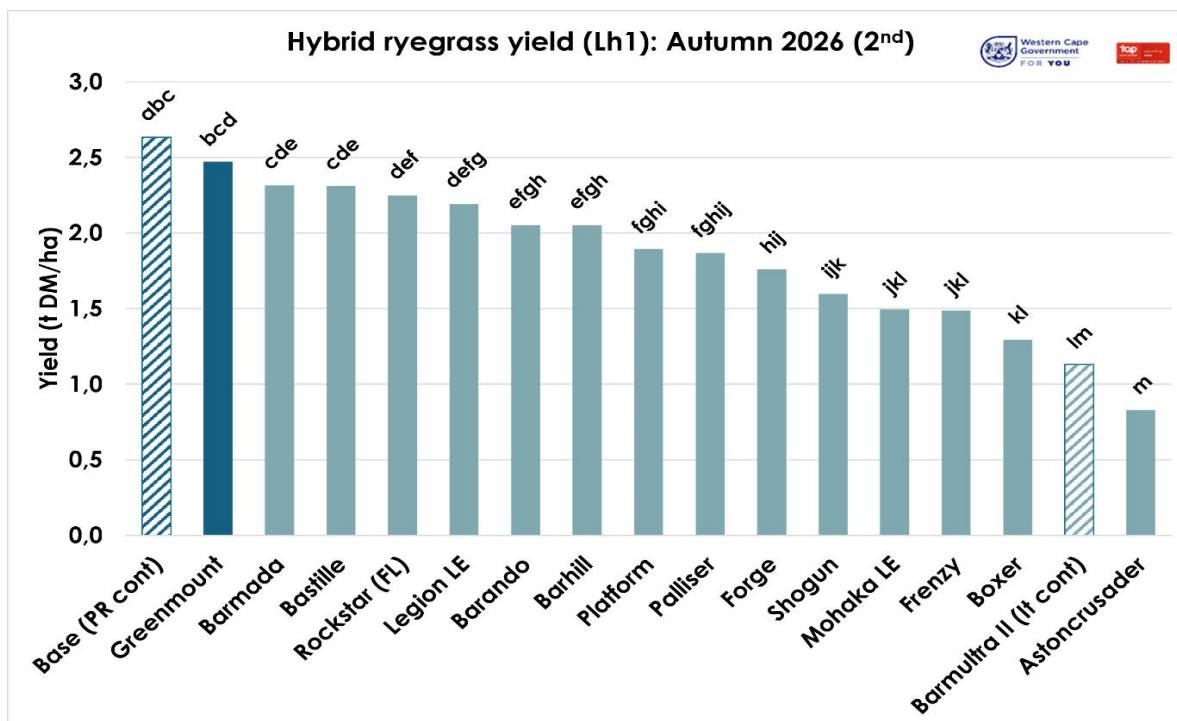


Figure 8. Dry matter yield (t DM/ha) for the second autumn 2026 (March to May) for trial Lh1. Yields with the same letter are similar ($p < 0.05$).

Seasonal growth rates

Seasonal growth rates (Table 2) are important indicators of whether there will be sufficient grazing to support the herd, especially the lactating dairy herd and their fodder flow needs. If we consider an example of what growth rate might be required, it can look as follows. The cows will preferably be required to graze year-round. If we assume a

450kg cow which will eat approximately 16kg DM/day of which 10kg DM/day may come from the pasture and we assume a stocking rate of 4 cows/ha and a wastage rate of 10%, then we will require a daily growth rate of 44kg DM/ha/day throughout the year. It would mean that in the surplus months any growth above this rate would need to be ensiled for feeding back in the months with the lower growth rates.

Table 2. Seasonal growth rates of hybrid ryegrass

Hybrid ryegrass (<i>Lolium x.hybridum</i>)			Outeniqua Research Farm, Trial Lh1									
Table 2: Seasonal Growth rates (kg DM/ha/day)			Planted 19 March 2025									
Cultivars	Species	Ploidy	Autumn 2025	Rank	Winter 2025	Rank	Spring 2025	Rank	Summer 2025/26	Rank	Autumn 2026	Rank
Astoncrusader	Hy II-type	T	25,70 ^{ghi}	20	22,90 ^{gh}	21	43,73 ^{cdef}	13	12,63 ^h	20	9,00 ^m	21
Barando	Hy II-type	D	33,43 ^a	2	36,37 ^{ab}	3	43,90 ^{cdef}	12	30,33 ^{cdef}	15	22,30 ^{efgh}	10
Barhill	Hy II-type	D	30,70 ^{abcdef}	10	28,20 ^{cdefg}	17	49,03 ^{abcd}	7	31,17 ^{cde}	14	22,30 ^{efgh}	9
Barmada	Hy II-type	T	31,37 ^{abcde}	8	26,97 ^{defg}	18	50,57 ^{abc}	4	36,47 ^{abc}	3	25,17 ^{cde}	5
Barmultra II	Italian	T	33,87 ^a	1	30,30 ^{bcdef}	14	51,13 ^{ab}	3	12,03 ^h	21	12,23 ^{lm}	20
Base	Perennial	T	28,23 ^{cdefg}	13	34,23 ^{abc}	8	42,57 ^{def}	16	36,43 ^{abc}	4	28,63 ^{abc}	3
Bastille	Hy II-type	T	32,47 ^{abc}	4	25,23 ^{fgh}	20	53,77 ^a	1	31,63 ^{bcde}	12	25,13 ^{cde}	6
Boxer	Hy II-type	T	27,27 ^{defghi}	16	28,30 ^{cdefg}	16	50,30 ^{abc}	5	21,50 ^g	19	14,07 ^{kl}	19
Forge	Hy PR-type	T	31,17 ^{abcde}	9	38,53 ^a	1	51,13 ^{ab}	2	24,07 ^{fg}	18	19,17 ^{hij}	15
Frenzy	Hy II-type	T	28,70 ^{bcdefg}	12	36,27 ^{ab}	5	48,27 ^{abcde}	8	31,40 ^{bcde}	13	16,17 ^{kl}	18
Legion AR37	Hy PR-type	D	27,30 ^{defghi}	15	33,87 ^{abc}	9	41,77 ^{ef}	19	35,90 ^{abcd}	5	29,83 ^{ab}	2
Legion LE	Hy PR-type	D	26,37 ^{fghi}	19	34,70 ^{abc}	7	41,50 ^{ef}	20	32,73 ^{bcde}	8	23,80 ^{defg}	8
LhM1904*	Hy II-type	T	31,60 ^{abcd}	6	36,30 ^{ab}	4	46,07 ^{bcdef}	11	40,27 ^a	1	26,83 ^{bcd}	4
Mohaka AR1	Hy II-type	T	30,43 ^{abcdef}	11	26,00 ^{efg}	19	46,80 ^{bcdef}	9	34,37 ^{abcde}	7	21,93 ^{efgh}	11
Mohaka AR37	Hy II-type	T	31,83 ^{abcd}	5	33,13 ^{abcd}	11	43,33 ^{def}	14	32,50 ^{bcde}	10	19,87 ^{ghij}	14
Mohaka LE	Hy II-type	T	26,47 ^{fghi}	18	28,43 ^{cdefg}	15	42,17 ^{def}	18	29,70 ^{def}	16	16,27 ^{kl}	17
Palliser	Hy II-type	T	26,90 ^{efghi}	17	32,33 ^{abcde}	12	42,90 ^{def}	15	35,87 ^{abcd}	6	20,30 ^{fghij}	13
Platform	Hy PR-type	D	23,33 ⁱ	22	30,83 ^{bcdef}	13	40,00 ^f	21	31,87 ^{bcde}	11	20,60 ^{fghi}	12
Platform AR37	Hy PR-type	D	23,53 ^{hi}	21	33,43 ^{abcd}	10	42,40 ^{def}	17	37,80 ^{ab}	2	32,70 ^a	1
Rockstar	FL Lolium-type	T	28,07 ^{cdefgh}	14	18,87 ^h	22	46,37 ^{bcdef}	10	32,73 ^{bcde}	9	24,40 ^{def}	7
Shogun	Hy II-type	T	31,43 ^{abcde}	7	34,97 ^{abc}	6	49,07 ^{abcd}	6	28,93 ^{ef}	17	17,37 ^{ijk}	16
Bandito 2	Hy Ww-type	T	33,23 ^{ab}	3	36,97 ^{ab}	2	23,57 ^g	22	1,17 ⁱ	22	0	22
LSD (0.05)			4,65		6,84		6,97		6,54		4,18	
CV%			9,66		13,3		9,39		13,6		12,5	

Yields with the same letter are statistically similar within a column * LhM1904 = Greenmount
Hy: Hybrid ryegrass; IT: Italian ryegrass; PR: perennial ryegrass; FL: Festulolium, Ww: Westerolds

Flowering behaviour

Flowering behaviour (Table 3) is important since reproductive tillers or bolting results in a higher stem component which implies a higher fibre content and thus lower forage quality and can be used as a rough proxy for forage quality (Stewart & Hayes 2011; Fulkerson & Travaskis 1997, van Vuuren 1993). The percentage of the sward that is reproductive varies significantly between cultivars due to vernalisation (cold days) requirements as does the duration

of reproductive tillers in the sward (flowering window, or aftermath flowering). Vernalisation takes place on a tiller basis and not on a tuft basis. In years with more “cold days” in winter the flowering incidence will be higher. Cultivars that do have a high bolting percentage could for instance be used for paddocks that will be cut for silage although it would also affect the silage quality as opposed to cutting a non-reproductive sward that is leafy. Cutting silage from a vegetative sward is desirable in terms of milk production (Stewart & Hayes 2011).

Table 3. Reproductive tillers (5) of hybrid ryegrass

Cultivars		Type	Cut 1 (21/4/2025)	Cut 2 (5/6/2025)	Cut 3 (16/7/2025)	Cut 4 (3/9/2025)	Cut 5 (9/10/2025)	Cut 6 (10/11/2025)	Cut 7 (11/12/2025)	Cut 8 (19/1/2026)	Cut 9 (18/2/2026)	Cut 10 (26/3/2026)	Cut 11 (20/5/2026)	Cut 12 (1/7/2026)	Summary	
							Early piping/ piping	Late piping/ early heading	Heading	Heading						
Astoncruader	T	0	0	0	0	25	cd	46	de	38	gh	17	cde	0	0	
Barando	D	0	0	0	0	25	cd	54	def	29	efg	13	bcd	0	0	
Barhill	D	0	0	0	0	29	d	54	def	46	h	21	def	0	0	
Barmada	T	0	0	0	0	4	a	71	fgh	17	bcde	4	ab	0	0	
Barmultra II	T	0	0	0	0	67	e	83	gh	83	i	38	g	0	0	
Base	T	0	0	0	0	0	a	0	a	13	abcd	0	a	0	0	
Bastille	T	0	0	0	0	8	ab	50	def	13	abcd	8	abc	0	0	
Boxer	T	0	0	0	0	8	ab	71	fgh	46	h	25	ef	0	0	
Forge	T	0	0	0	0	21	bcd	46	de	29	efg	13	bcd	0	0	
Frenzy	T	0	0	0	0	13	abc	50	def	21	cdef	21	def	0	0	
Legion AR37	D	0	0	0	0	0	a	8	a	8	abc	0	a	0	0	
Legion LE	D	0	0	0	0	0	a	0	a	0	a	0	a	0	0	
LhM1904*	T	0	0	0	0	8	ab	17	abc	17	bcde	17	cde	0	0	
Mohaka AR1	T	0	0	0	0	13	abc	38	cd	33	fgh	25	ef	0	0	
Mohaka AR37	T	0	0	0	0	25	cd	33	bcd	25	defg	25	ef	0	0	
Mohaka LE	T	0	0	0	0	13	abc	38	cd	33	fgh	29	fg	0	0	
Palliser	T	0	0	0	0	4	a	13	ab	4	ab	4	ab	0	0	
Platform	D	0	0	0	0	0	a	8	a	4	ab	0	a	0	0	
Platform AR37	D	0	0	0	0	0	a	8	a	0	a	0	a	0	0	
Rockstar	T	0	0	0	0	21	bcd	42	de	38	gh	17	cde	0	0	
Shogun	T	0	0	0	0	33	d	63	efg	33	fgh	21	def	0	0	
Bandito 2	T	0	0	0	0	88	f	88	h	100	j	-	-	-	-	
LSD (0.05)						16,4		23,0		13,1		11,9				
CV%						54		35,0		27,8		51,2				
Reproductive tillers % with the same letter are statistically similar within a column										* LhM1904 = Greenmount						

Leaf rust incidence

Leaf rust incidence (Table 4) refers mainly to crown rust (*Puccinia coronata*). According to Clarke & Eagling (1994) and Webb et al (2019) crown rust causes yield loss as well as negative effects on root weight and rooting depth, tiller numbers and leaf area or photosynthetic area. Potter (2007) reported not only reduced yield but also reduced water-soluble carbohydrates and reduced digestibility. Plummer et al (1990) also refers to reduced tiller density and increased tiller death. Carr (1975) reports rust to be a

water-soluble carbohydrate (WSC) sink that reduces growth and forage quality. Additionally, Carr (1975) estimates that 10% leaf rust infection could cause up to 50% decline in WSC concentration. Hence there are advantages to cultivars which are resistant or have a low incidence only.

Rust can be more severe under nutrient deficiency conditions or if growth cycles are allowed to continue beyond the 3-leaf stage. Increased dead leaf matter may also increase facial eczema (McKenzie 1971).

Table 4. Rust incidence of hybrid ryegrass

 Western Cape Government FOR YOU		Hybrid ryegrass (<i>Lolium x. hybridum</i>)										Outeniqua Research Farm, Trial Lh1									
		Table 4: Rust % (ratings based)										Planted 19 March 2025									
Cultivars	Type	Cut 1 (29/4/2025)	Cut 2 (3/6/2025)	Cut 3 (16/7/2025)	Cut 4 (3/9/2025)	Cut 5 (9/10/2025)	Cut 6 (10/11/2025)	Cut 7 (11/12/2025)	Cut 8 (19/1/2026)	Cut 9 (18/2/2026)	Cut 10 (26/3/2026)	Cut 11 (20/5/2026)	Cut 12 (11/7/2026)	Summary							
Astoncruader	T	0	0	0	4 ab	25 cd	21 abcdef	42 bdefg	83 cd	50 ef	0	4 ab	0								
Barando	D	0	0	0	0 a	0 a	4 ab	25 abcd	58 a	4 a	0	0 a	0								
Barhill	D	0	0	0	0 a	0 a	4 ab	13 a	58 a	21 abc	0	0 a	0								
Barmada	T	0	0	0	0 a	0 a	29 cdef	21 abc	67 ab	17 abc	0	4 ab	0								
Barmultra II	T	0	0	0	50 c	29 cd	25 bdef	54 efghi	88 d	-	0	13 abcd	0								
Base	T	0	0	0	8 ab	17 bc	42 f	71 gi	88 d	25 abcd	0	17 bcd	0								
Bastille	T	0	0	0	0 a	0 a	8 abc	13 a	71 abc	13 ab	0	13 abcd	0								
Boxer	T	0	0	0	4 ab	8 ab	38 ef	42 bdefg	83 cd	50 ef	0	4 ab	0								
Forge	T	0	0	0	4 ab	8 ab	33 def	79 i	83 cd	46 def	0	13 abcd	0								
Frenzy	T	0	0	0	0 a	0 a	13 abcde	17 ab	83 cd	29 bcde	0	8 abc	0								
Legion AR37	D	0	0	0	0 a	0 a	8 abc	33 abcdef	79 bcd	4 a	0	13 abcd	0								
Legion LE	D	0	0	0	0 a	0 a	4 ab	29 abcde	75 bcd	13 ab	0	13 abcd	0								
LhM1904*	T	0	0	0	4 ab	0 a	17 abcde	50 defgh	67 ab	33 bcde	0	21 cde	0								
Mohaka AR1	T	0	0	0	4 ab	17 bc	25 bdef	54 efghi	88 d	38 cdef	0	25 de	0								
Mohaka AR37	T	0	0	0	4 ab	0 a	13 abcd	46 cdefgh	83 cd	38 cdef	0	17 bcd	0								
Mohaka LE	T	0	0	0	4 ab	0 a	17 abcde	58 fghi	88 d	38 cdef	0	13 abcd	0								
Palliser	T	0	0	0	0 a	0 a	17 abcde	33 abcdef	79 bcd	21 abc	0	8 abc	0								
Platform	D	0	0	0	0 a	0 a	8 abc	38 abcdef	79 bcd	17 abc	0	21 cde	0								
Platform AR37	D	0	0	0	0 a	0 a	0 a	46 cdefgh	75 bcd	13 ab	0	33 e	0								
Rockstar	T	0	0	0	13 b	33 d	42 f	54 efghi	83 cd	33 bcde	0	17 bcd	0								
Shogun	T	0	0	0	8 ab	17 bc	33 def	67 fgi	83 cd	58 f	0	21 cde	0								
Bandito 2	T	0	0	0	0 a	0 a	4 ab	38 abcdef	-	-	-	-	-								
LSD (0.05)		NS	NS	NS	8,7	12,7	24,8	29,1	14,3	21,2	NS	13,0	NS								
CV%					106,7	110	81,9	42,1	11,1	45,9		60,2									
Reproductive tillers % with the same letter are statistically similar within a column																					
* LhM1904 = Greenmount																					

Reproductive tillers % with the same letter are statistically similar within a column

* LhM1904 = Greenmount

Hybrid ryegrass (*Lolium x. hybridum*)

Outeniqua Research Farm, Trial Lh1

Table 5: Sward density % (ratings based)

Planted 19 March 2025

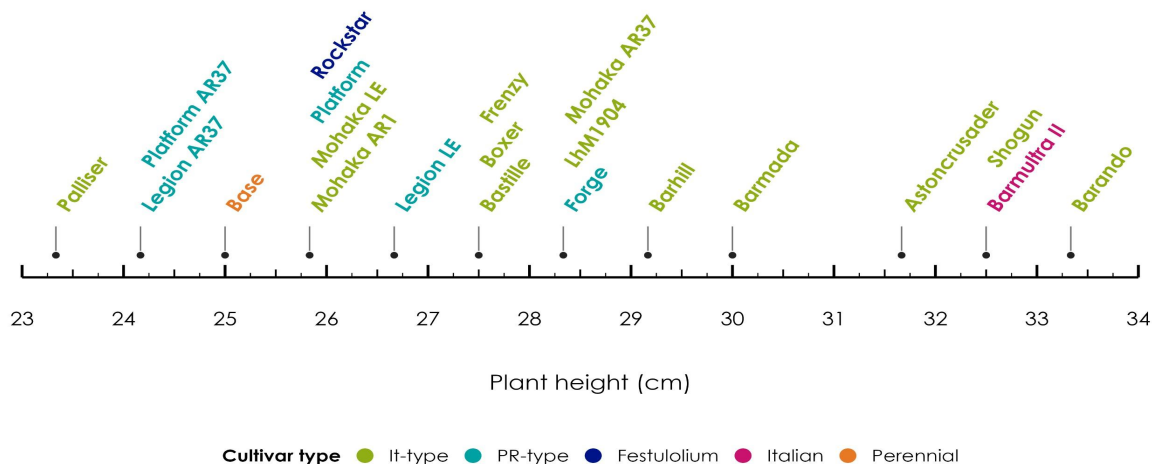
Cultivars	Type	Cut 1 (29/4/2025)	Cut 2 (5/6/2025)	Cut 3 (16/7/2025)	Cut 4 (3/9/2025)	Cut 5 (9/10/2025)	Cut 6 (10/11/2025)	Cut 7 (11/12/2025)	Cut 8 (19/1/2026)	Cut 9 (18/2/2026)	Cut 10 (26/3/2026)	Cut 11 (20/5/2026)	Cut 12 (1/7/2026)	Summary
Astoncruader	T	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	83 ^b	29 ^e	8 ^f	83 ^c	92 ^b	
Barando	D	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	100 ^a	92 ^{ab}	79 ^{cd}	96 ^{ab}	100 ^a	
Barhill	D	100	96 ^{ab}	100	100	100 ^a	100 ^a	100 ^a	100 ^a	83 ^{bc}	79 ^{cd}	96 ^{ab}	96 ^{ab}	
Barmada	T	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	
Barmultra II	T	100	96 ^{ab}	100	100	100 ^a	100 ^a	100 ^a	79 ^c	0 ^f	13 ^f	92 ^{abc}	96 ^{ab}	
Base	T	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	96 ^{ab}	100 ^a	
Bastille	T	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	96 ^{ab}	100 ^a	100 ^a	
Boxer	T	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	100 ^a	58 ^d	63 ^e	92 ^{abc}	96 ^{ab}	
Forge	T	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	100 ^a	63 ^d	54 ^e	96 ^{ab}	100 ^a	
Frenzy	T	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	100 ^a	79 ^c	67 ^{de}	88 ^{bc}	100 ^a	
Legion AR37	D	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	
Legion LE	D	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	88 ^{abc}	96 ^{ab}	100 ^a	
LhM1904*	T	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	
Mohaka AR1	T	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	88 ^{abc}	100 ^a	100 ^a	
Mohaka AR37	T	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	88 ^{abc}	96 ^{ab}	100 ^a	
Mohaka LE	T	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	100 ^a	92 ^{ab}	79 ^{cd}	92 ^{abc}	100 ^a	
Palliser	T	100	96 ^{ab}	100	100	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	83 ^{bc}	96 ^{ab}	100 ^a	
Platform	D	100	96 ^{ab}	100	100	100 ^a	100 ^a	100 ^a	100 ^a	96 ^a	79 ^{cd}	96 ^{ab}	100 ^a	
Platform AR37	D	100	92 ^{ab}	100	100	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a	
Rockstar	T	100	100 ^a	100	100	100 ^a	100 ^a	100 ^a	100 ^a	92 ^{ab}	88 ^{abc}	100 ^a	100 ^a	
Shogun	T	100	96 ^{ab}	100	100	100 ^a	100 ^a	100 ^a	100 ^a	79 ^c	67 ^{de}	92 ^{abc}	100 ^a	
Bandito 2	T	100	96 ^{ab}	100	100	83 ^b	71 ^b	25 ^b	-	-	-	-	-	
LSD (0.05)		NS	6,7	NS	NS	2,5	2,5		3,6	12,2	15,5	11,0	5,1	
CV%			4,1			1,6	1,6		2,2	8,8	12,2	7,0	3,1	

Reproductive tillers % with the same letter are statistically similar within a column

* LhM1904 = Greenmount

Sward density ratings (Table 5) give an indication of persistence especially in the summer months. The cultivars that retain good sward density or plant population throughout the summer are desirable in terms of yield but also ground cover which in turn relates to weed ingress potential.

Sward height varies for the different types of hybrids. The diagram below shows the heights in the vegetative phase as measured at the second harvest. This data gives a relative comparison of how tall the different cultivars grow in relation to each other. Generally, the Italian-type hybrids grow taller than the perennial-type hybrids.



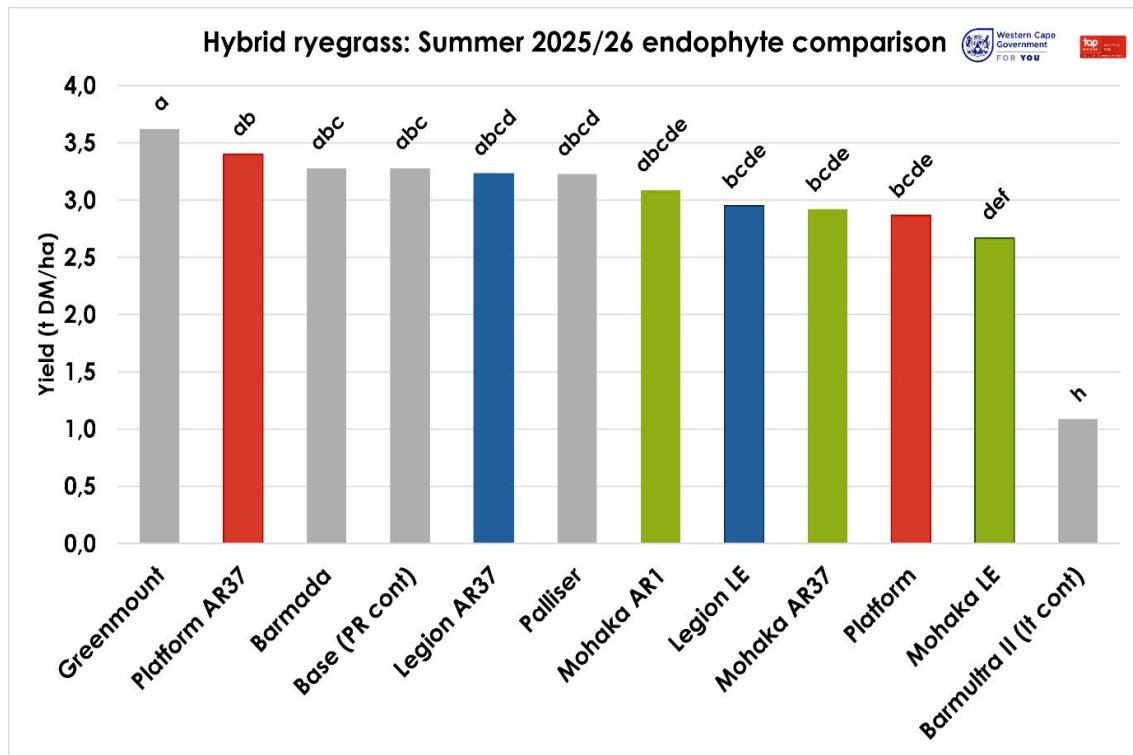


Figure 9. Summer yield of perennial-type hybrid ryegrass cultivars Platform and Legion with endophyte AR37, Platform without endophyte and Legion with low endophyte (LE); and Italian-type hybrid ryegrass cv. Mohaka with AR1, AR37 and low endophyte (LE). The cultivars Base and Barmultra II are the controls while the remaining cultivars Greenmount, Barmada and Palliser are the other best yielding cultivars in the trial for the summer season.

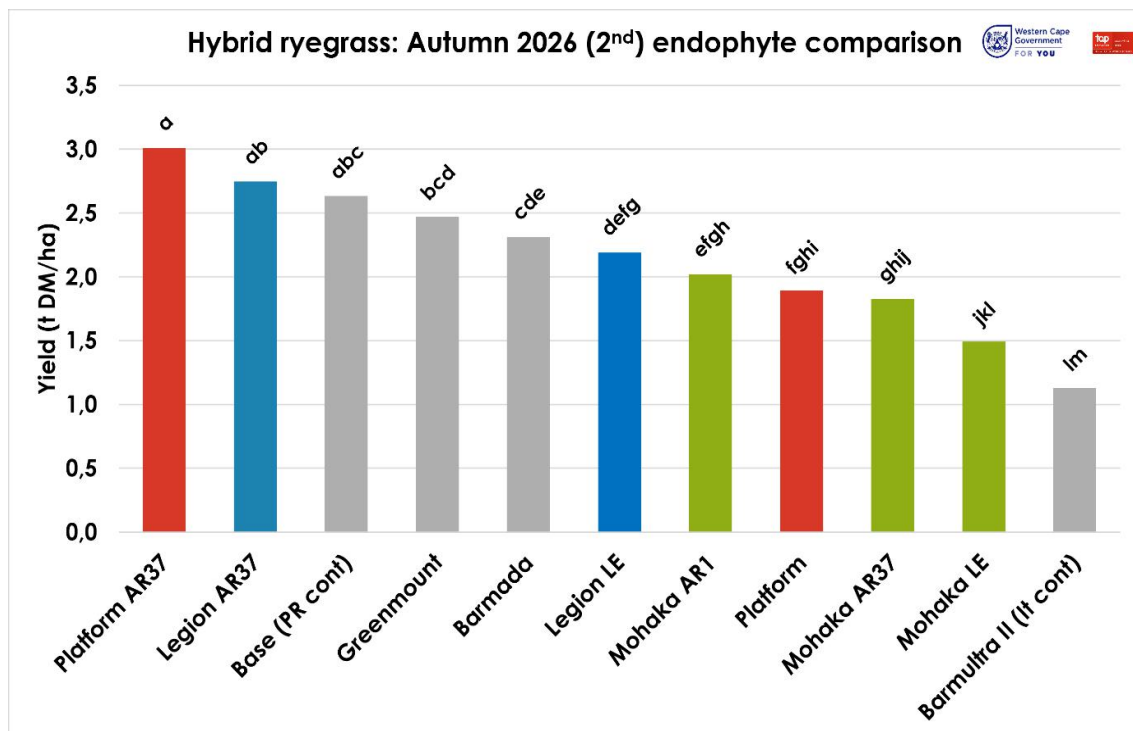


Figure 10. Second autumn yield of perennial-type hybrid ryegrass cultivars Platform and Legion with endophyte AR37, Platform without endophyte and Legion with low endophyte (LE); and Italian-type hybrid ryegrass cv. Mohaka with AR1, AR37 and low endophyte (LE). The cultivars Base and Barmultra II are the controls while the remaining cultivars Greenmount and Barmada are the other best yielding cultivars in the trial for the second autumn season.

Summary

- Best yielding cultivars over the first year (March 2025 to Feb 2026): Greenmount (LhM1904), Barmada, Forge, Frenzy, Shogun, Barando, Bastille
- Best yielding cultivars over 15 month period (March 2025 to May 2026): Greenmount, Barmada, Bastille, Barando
- Fastest during establishment season for yield (first autumn March to May 2025): Barando, Bastille, Greenmount, Shogun, Barmada, Forge, Barhil.
- Best winter yield (June to August 2025): Forge, Barando, Greenmount, Frenzy, Shogun, Legion LE, Palliser.
- Best summer yield (December 2025 to February 2026): Greenmount, Barmada, Palliser.
- Best second autumn (March to May 2026): Greenmount. Similar: Barmada, Bastille, Rockstar, Legion LE.
- Cultivars that were in the highest yielding group for both winter and summer: Greenmount and Palliser.
- Cultivars containing endophyte AR37: Platform AR37 and Legion AR37.

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PASTURE RENOVATION: A GAME OF HIT AND MISS.....

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Introduction

In 2016 the first small plot evaluation trials in South Africa for chicory (*Chicorium intybis*), plantain (*Plantago lanceolata*) and mixtures containing these species were established at the Outeniqua Research Farm (Ammann 2019). Results showed great promise in addressing the two major challenges being experienced within the kikuyu-ryegrass systems, namely: poor persistence of the temperate ryegrass component and low milk yield during the summer/autumn due to the low forage quality of kikuyu. Chicory, plantain, Tall Fescue (*Festuca arundinacea*) and mixtures of these species all out-yielded perennial ryegrass over a three year period and had the potential to produce high quality forage during summer/autumn (Amman 2018, Ammann 2020). Amidst concerns that these pasture types would not be able to establish successfully using no-till methods, be persistent under grazing or would suppress milk fat due to their low fibre content, a farmlet study was conducted on the Outeniqua Research Farm from 2019 to 2022. Results from this large scale study under grazing confirmed the theory that forage herbs could revolutionize pasture systems in the southern Cape, when all systems that had a forage herb component achieved higher milk yields from spring through to autumn than the traditional kikuyu-ryegrass system (van der Colf 2022).

Irrespective of all these positive results, there still seems to be a large degree of hesitancy amongst producers and consultants to transform notable areas on of the pasture platform to forage herb based systems. This hesitancy is largely based on the lower degree of predictability of

mixtures in terms of yield, persistence and changes in botanical composition. Push back has further been linked to a lack of concise management guidelines in terms of what combinations of species are most suitable and when management interventions in terms of renovation, over-sowing or complete re-establishment should occur. Hesitancy is also based on by a move away from typical ryegrass or grass-legume pastures that were well researched in South Africa, New Zealand and Australia, to mixtures that are now more complex, with three functional groups (grass, legume and forage herb) and often in excess of 4 species (for example, chicory, plantain, Lucerne, clovers, ryegrass). Although small plot trials can form the basis of some of these decisions, mixtures and species may react differently when additional stressors are added to the system such as trampling, grazing and high rates of weed ingress (Tozer et al. 2016).

The aim of this study was to develop establishment and renovation management guidelines for diverse pasture mixtures that contain a grass, legume and forage herb and when intensively grazed by dairy cows in the southern Cape.

Materials and methods

The study was carried out on the Outeniqua Research Farm (altitude 210 m, 33°58'38" S and 22°25'16"E) in the Western Cape Province of South Africa from March 2023 to March 2026. The mean annual rainfall (30 year average) in this area is 725 mm, with mean minimum and maximum temperatures ranging between 7-15°C and 18-25°C respectively (ARC 2010).

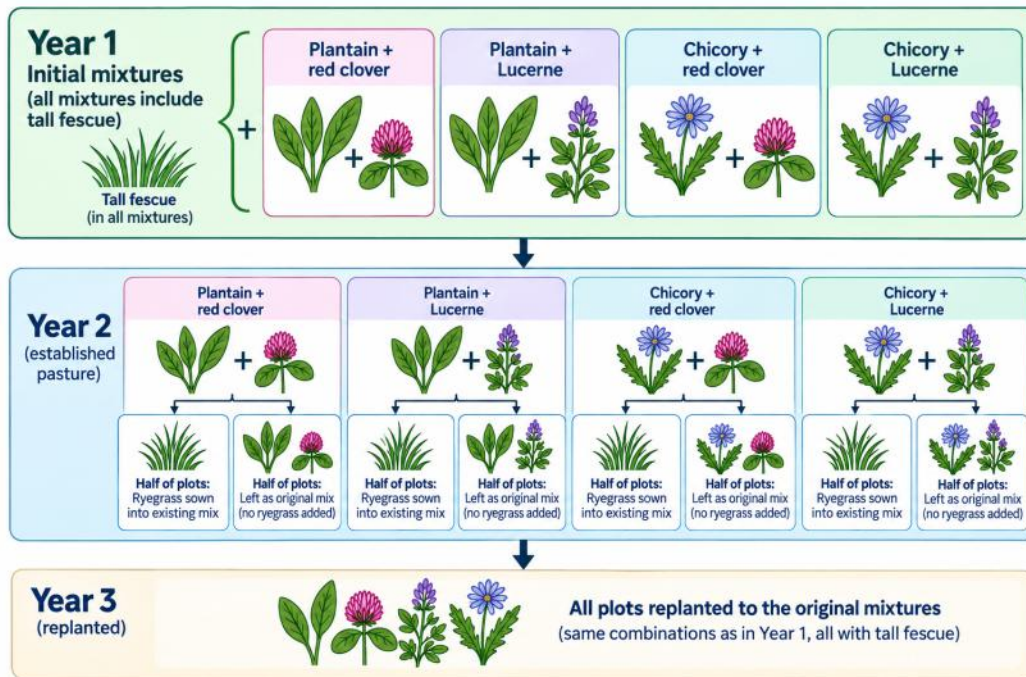


Figure 1. The approach to pasture renovation during the project period. Seeding rates were 20 kg/ha Tall fescue; 4 kg/ha Plantain; 3 kg/ha; Chicory; 3 kg/ha Red clover and 8 kg/ha 8 kg/ha Lucerne. Perennial ryegrass was planted in at 12 kg/ha during year 2.

Pasture renovation treatments

The approach of the project to pasture mixtures and re-enforcement/oversowing practices is shown in Figure 1.

Four pasture mixtures were evaluated, all with Tall Fescue as the grass component, but differing in terms of the forage herb/legume combination as follows:

1. Chicory_Lucerne
2. Chicory_Red clover
3. Plantain_Lucerne
4. Plantain_Red clover

In January 2023 existing pastures were sprayed with herbicide, with a follow up spray occurring in February to prepare the identified paddocks (6 ha) for establishment. In March 2023 all mixtures were planted with a Piket 12 row no till cover crop fine seed planter, with the forage herb and legume seed placed in one seed tray and the grass seed placed in another. These were the "primary treatments". In March 2024, half of the plots of each mixture type were over-sown (OS) with perennial ryegrass at 12 kg/ha, while the other half was left as is (no action taken). In the next year (March 2025) all plots were re-enforced by planting the original mixtures again into the existing sward.

Pasture management

Literature on nitrogen fertilisation of pasture mixtures containing forage herbs and alternative legumes to white

clover (like Lucerne and red clover) is both limited and highly variable in the final recommendation made by authors. In addition, no such published research exists for these pasture types when managed within long term minimum till pastures in the southern Cape. However, from some cited articles (see literature review) and discussions with an experienced soil scientist (N Miles) it was decided to fertilise pastures at a rate of 28 kg/ha after grazing.

Pastures were grazed by Jersey cows from the Outeniqua Research Farm Dairy herd. The decision on when to graze (grazing interval) was based on entering pastures when the fescue based pasture is at the 2.5 leave stage. In order to allocate pasture to achieve a post grazing height of between 4 and 5 cm, pre-grazing pasture yield was measured using a RPM and pasture allocated at approximately 5 kg DM cow/grazing.

Measurements

Although pasture yield was determined, it will not be reported on here, but it will rather focus on changes in botanical composition. Seasonal botanical composition was estimated by placing three 0.098 m² rings randomly within a sub-plot per strip before grazing and cutting samples to a height of 50 mm above ground. The three samples will be separated into the relevant fractions for each pasture type namely: sown grass; sown legume, sown forage herb, volunteer grasses, volunteer legumes, volunteer forage herbs and broadleaf weeds. Samples were dried at 70°C for 72 hours to a constant mass and weighed to determine the contribution on a DM basis.

Results and discussion

In this article, only botanical composition will be discussed as the primary purpose is to determine the impact of establishment and re-enforcement strategies related to different species and mixture combinations. Points in the production cycle will be focused on:

Winter 1: The winter after establishment to determine the success of establishment and initial weed load

Summer 1: The summer after establishment (summer 1) to determine persistence of the sown components over the first year.

Winter 2: The contribution of the ryegrass over-sown in the autumn of year winter to the subsequent winter's sward (winter 2).

Summer 3: The sward composition in the third summer after establishment to determine if over-sowing all sward components in autumn of year two maintained/improved composition.

Sward composition during the establishment year

The contribution of the sown components and weeds to sward composition of the mixtures in the winter 1 (after establishment) are shown in Figure 2 and 3, respectively. The first point of interest from botanical composition data of the first winter after an autumn establishment was that planting Tall fescue as a monoculture resulted in a notably higher fescue component than in mixtures. However, the weed content in these pastures both in the form of volunteer/weedy grasses (*Bromus catharticus*; *E. plana*; *Paspalum spp.*; *Cenchrus clandestinus*) and broadleaf weeds was also higher than the forage herb-legume mixtures. This confirms earlier findings on Outeniqua that forage herbs hold the potential to suppress weeds during the establishment year to some degree.

When planted in a mixture, the Tall fescue component tended to be favoured by the inclusion of plantain rather

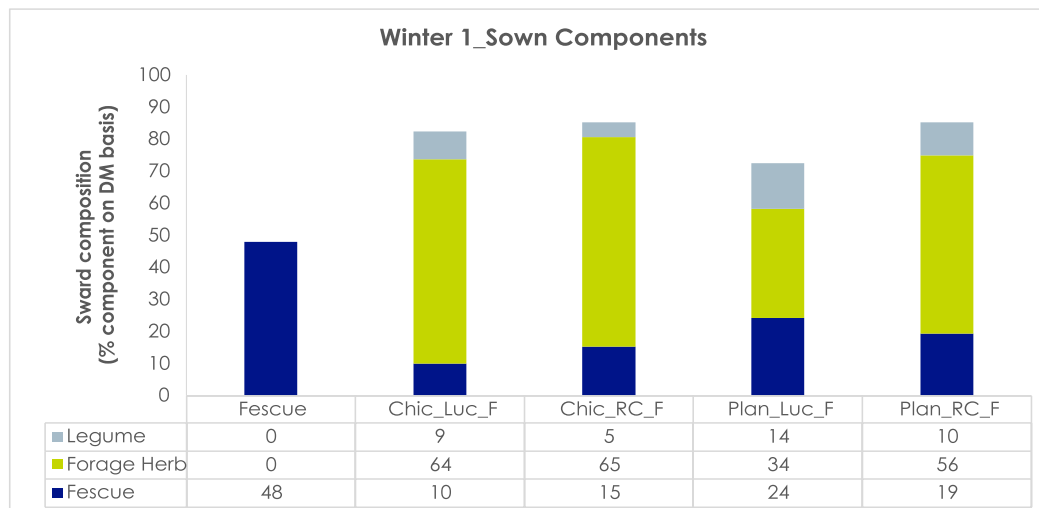


Figure 2. The botanical composition (%) of Fescue mixtures in terms of the legume, forage herb and fescue component during winter 1

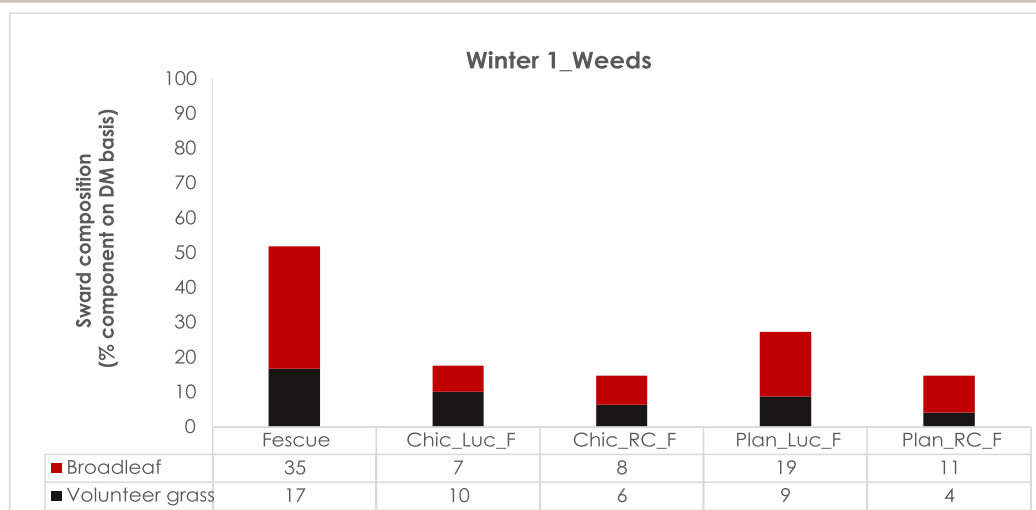


Figure 3. The botanical composition (%) of Fescue mixtures in terms of volunteer grasses and broadleaf weeds during winter 1.

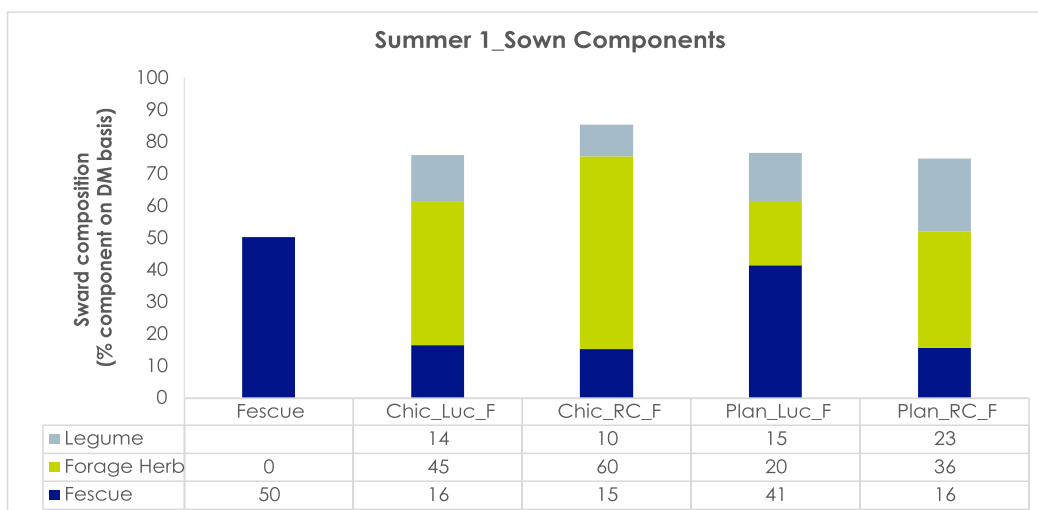


Figure 4. The botanical composition (%) of Fescue mixtures in terms of the legume, forage herb and fescue component during summer of year 1

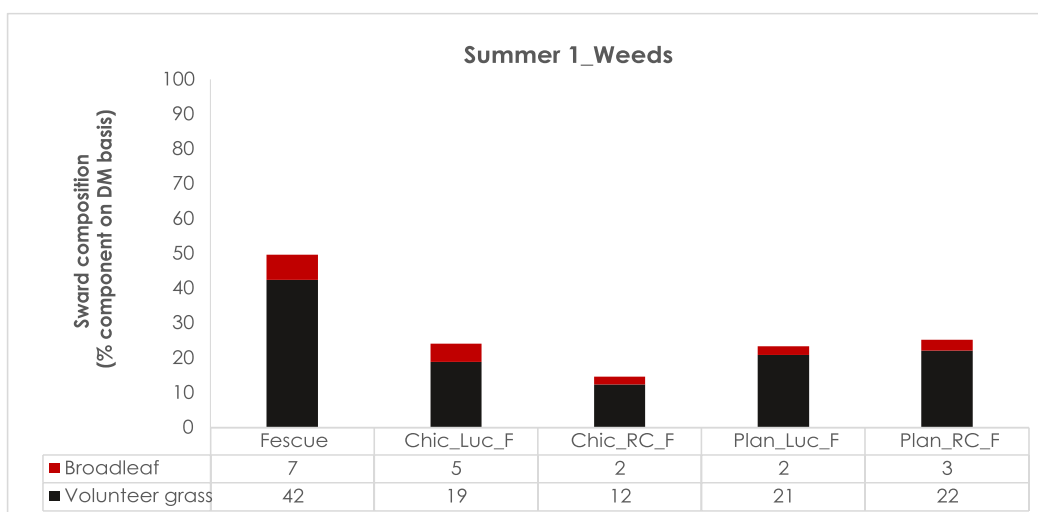


Figure 5. The botanical composition (%) of Fescue mixtures in terms of volunteer grasses and broadleaf weeds during summer 1.

than chicory, likely due to the more competitive growth of the chicory during the establishment phase. A similar pattern was noted for the legume components, with both being slightly higher in the plantain versus the chicory mixtures during the first winter after establishment.

Summer is often when producers evaluate pastures to earmark for total re-establishment or only re-enforcement with specific components. The contribution of sown components and weeds to the composition of Tall fescue mixtures is shown in Figure 4 and 5, respectively. The composition dynamics observed in winter were still apparent at this point, with chicory still contributing more to the sward than plantain as a forage herb component. With the exception of lucerne in the Plantain/Lucerne mixture, the legume component had stabilised across mixtures, contributing less than 20%.

The effectiveness of over-sowing perennial ryegrass

Over-sowing/re-enforcement with perennial ryegrass on an annual basis has been recommended to "fill gaps" both spatially in the pasture mixtures and to improve winter fodder-flow. Figure 5 shows the contribution of ryegrass to mixture swards that were over-sown (OS) with perennial ryegrass (12 kg/ha) or where no action was taken. Results were very poor, with ryegrass contribution less than 10% in all treatments. The reason for this is not clear, but is hypothesized that either a more competitive component be planted in (annual or hybrid ryegrass), or that a planter that causes slightly more disturbance could result in better establishment. The effect of the latter strategy on the perennial components (forage herbs, legumes and Tall Fescue) will have to be quantified, however.

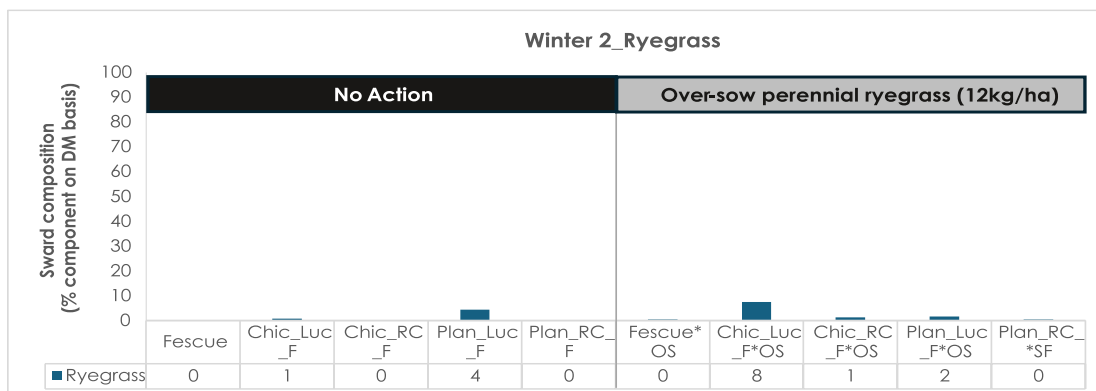


Figure 6. The contribution (%) of perennial ryegrass to sward composition in winter 2 when the mixtures were either left as is (no action) or over-sown with ryegrass in the autumn

Maintenance of sward composition over years

The total sown component % during summer of year 1, 2 and 3 are shown in Figure 7. The contribution of the sown components and weeds to sward composition of the mixtures in the summer 3 (after establishment) are shown in Figure 8 and 9, respectively.

All mixtures showed a decline in sown components from year 1 to year 2, then a slight increase in year 3. It thus appears that re-enforcing the perennial components in the years following establishment could improve composition, although it did not reach the same values as in the establishment year for any of the mixtures. With the sown component still contributing on average less than 60%

across all treatments in year 3 even with the intervention of planting in all the components in year 2, the advantages should be weighed up against the cost carefully.

At a glance, the Plantain/Lucerne/Fescue mixture, followed by the Chicory/Lucerne/Fescue would be the most favourable choice as both maintained the most favourable composition in terms of total sown component versus weeds into year 3. However, for both of these combinations, the forage herb component was lower than when combined with red clover. In general it is recommended that forage herbs contribute 60% to the sward for maximum forage quality advantages, legumes 30% for nitrogen fixation benefits and the rest should be made up of a grass. However none of the mixtures

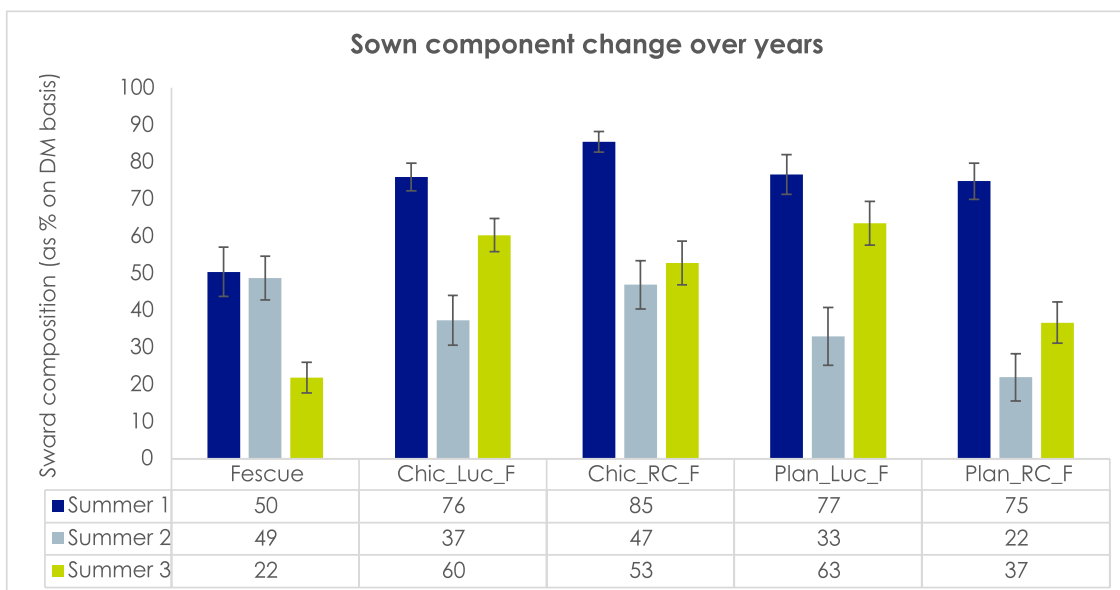


Figure 7. The change in contribution of all sown components (Fescue + Forage Herbs + Legumes) from summer 1 to summer 3

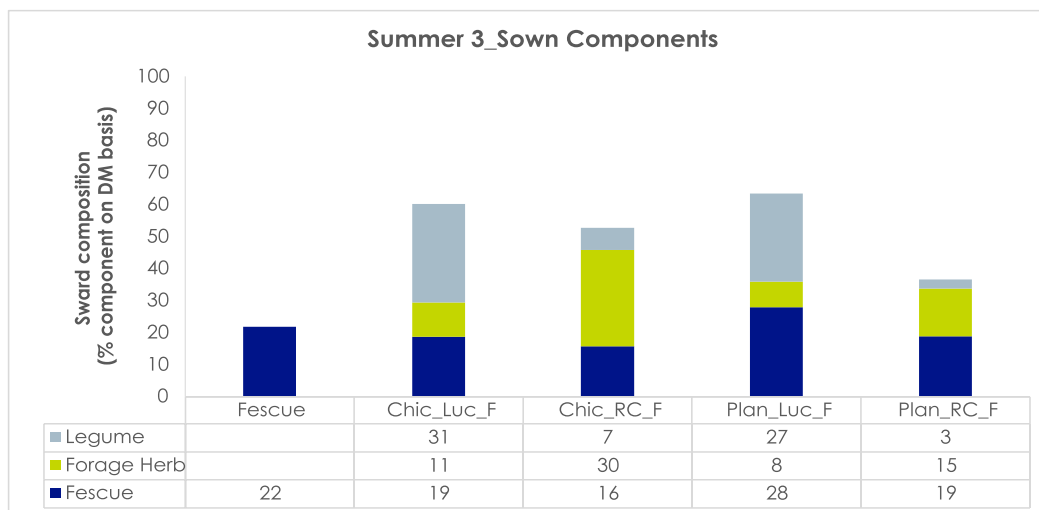


Figure 8. The botanical composition (%) of Fescue mixtures in terms of the legume, forage herb and fescue component during summer of year 3

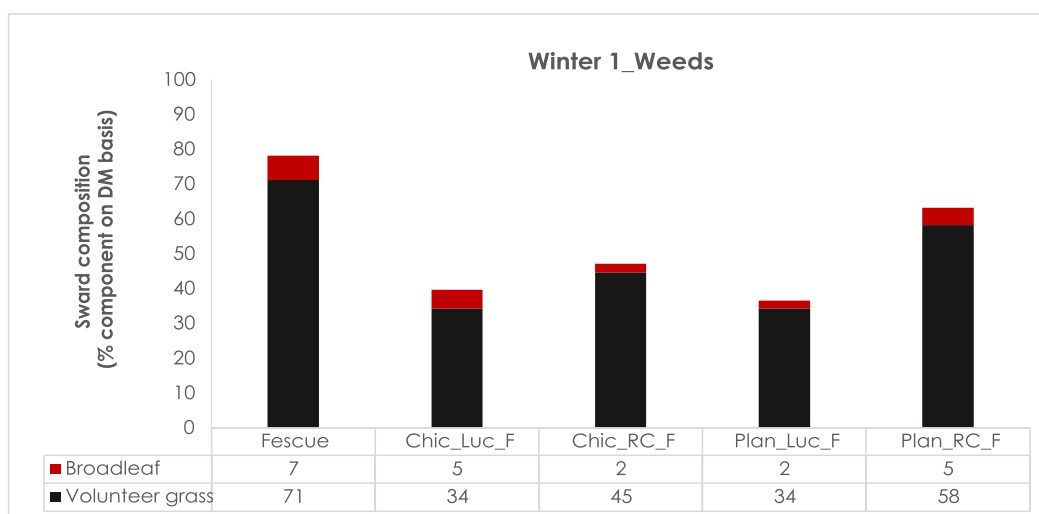


Figure 9. The botanical composition (%) of Fescue mixtures in terms of volunteer grasses and broadleaf weeds during summer 3.

achieved this perfect balance. Keeping in mind that a previous system trial conducted on Outeniqua, forage herb content drives the forage quality of these pasture mixtures, mixtures that favour the forage herb component such as those with red clover should be considered. However, if the legume component is the primary focus, lucerne inclusion in combination with plantain or chicory should be considered.

Conclusion

The selection of species for inclusion in mixtures has become a hotly debated topic in the pasture based dairy industry. From shotgun mixtures with high seeding rates to personal preferences, the recommendations are endless. From this study it is apparent that none of the mixtures included met the golden standard of 60% forage herbs and 30% legume. However, the results reported again

highlight that the primary challenge in these systems still remains the high weed load pastures experience, both during the establishment phase and as the pasture "ages over years". Even if this were over-come, producers will have to decide what their focus is going to be: legumes or forage herbs. If they want a higher legume component, lucerne should be their primary component, while red clover would achieve a more balanced forage herb component. However, further investigation needs to be done into specific sward dynamics to determine which forage herb would achieve the most favourable sward composition and forage quality synergy.

In terms of re-enforcement strategies, a more annual competitive species like annual or hybrid ryegrass would be preferable to a perennial ryegrass, while "trickling in" forage herbs and legumes is another option. Although re-enforcing pastures could improve composition to some

degree, careful consideration should be given to the cost versus benefit balance.

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perennial ryegrass, tall fescue, chicory and plantain.

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CHICORY AND PLANTAIN: YIELD, FORAGE QUALITY AND DISEASE RESISTANCE

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Introduction

The production potential of chicory (*Cichorium intybus*) and plantain (*Plantago lanceolata*) cultivars was assessed from a late spring planting in November 2024 for chicory and a late summer planting for plantain in February 2025 in trial no. Fh12. Forage herbs are most productive in the warmer months of the year, but the best cultivars yield equally well to ryegrass in the winter months, if the winter temperatures are not too low. The advantage of chicory and plantain is this high productivity in spring, summer and into autumn, which tend to be the more challenging months for temperate grasses. Additionally the criterion for suitable cultivars is that they are not winter dormant and should retain a good plant population for at least two years. The deep root system of both plantain (fibrous root system) and especially chicory (tap root) is valuable for accessing water and nutrients and providing carbon related to root growth into the deeper soil layers. This translates into improved resilience of the pasture.

Both these species are commonly utilized in mixed pastures but can also be utilized in pure stands and then often alternately grazed with a grass pasture. Forage herbs are highly digestible, generally high in energy and should be used in combination with suitable fibre and a suitable concentrate, depending on the levels of feeding. More detailed information about the species, basic management principles and the different types of cultivars is available in the 2017, 2018 and 2019 Outeniqua Information Day booklets.

The data reported on in this article is from the cultivar evaluation trial planted on the Outeniqua Research Farm trial no. Fh12. The planting date for chicory was 18

November 2024 and the plantain 18 February 2025. The trial consists of 10 chicory and three plantain cultivars sown at 10 kg/ha. The first harvest was done after the cultivars had at least six fully extended leaves. Thereafter harvests were determined by sward height. Generally, for plantain between 25 and 30 cm and chicory 30 to 40cm depending on the time of the year. Harvesting was done with a reciprocating mower at 5cm blade height with the entire net plot weighed and sampled.

Cultivars in the trial

- Chicory: Betti Berdea, Chico, Commander, Estero Quality, Lacerta, Rocket Fuel, Sika, Six Point, Spadona, Thrive
- Plantain: Agritonic, Captain, Tonic

Parameters reported in this article

- Total yield
- Seasonal yield
- Growth rates
- Flowering incidence
- Leaf component during flowering (grazable yield)
- Leaf disease incidence
- Height at harvesting
- Persistence/sward density
- Plant population count after year 1
- Forage quality
- Dry matter %

Trial design and management

The trial is designed as a Randomised Block Design with three replications. Gross plot size is 2.1m x 5m and net plot size is 1.3m x 3.7m. Both chicory and plantain are sown at

10kg/ha as pure stands with rows spaced 15cm apart. All seed was uncoated. If coated seed were to be used the seeding rate would have to be adapted accordingly to achieve the same seeding rate.

The trial is harvested according to height as most plots. However, time from establishment to first harvest is the emergence of six to seven fully extended leaves. Target pre-harvest height for chicory is between 30 to 40cm and plantain 25 to 30cm, depending on the time of the year. Plots are cut with a reciprocating mower (Agria) at 5cm height. The material from the net plot is sampled for dry matter determination with an approximately 500g wet weight sample and the rest of the material is raked together and weighed as the plot weight. Samples are weighed and oven dried at 70°C.

The trial is top-dressed with nitrogen fertilizer after each harvest, and potassium fertilizer to account for nutrient removal, since all material is removed from the trial.

Irrigation was applied weekly if necessary, according to soil moisture probes to add to the rainfall and after fertilization.

Results

Total yield (Table 1) is important since the establishment and input costs are similar regardless of yield, hence the importance of choosing the cultivars with the best yield (Figure 1). These species are part of the pasture system year-round even though they are more productive in the

warmer months. In mixed pastures that contain chicory and plantain it is also possible to make silage of surplus yield. Yield data of the previous cultivar evaluation trial Fh1 and Fh5 are contained in the Outeniqua Information Day books for 2019 and 2023.

Seasonal yield (Table 1) is important for fodder flow purposes and to choose the best cultivars for the seasons that are most challenging in terms of fodder flow needs. For chicory and plantain the yields in summer (Figure 2 and Figure 3) and autumn (Figure 4 and Figure 5) are valuable in relation to the yield challenges of ryegrass in summer and the over-sowing in autumn resulting in an extended grazing rotation on many paddocks on the farm. The winter yield (Figure 6) is important since there are cultivars that do have winter-active growth which can also contribute to the yield in the cooler months. The plantain cultivars have more active winter growth than the chicory cultivars.

The yield of the second summer (Figure 3) for the chicory cultivars was approximately 1 tDM/ha more than the first summer (Figure 2). This was due to the establishment phase after planting until the plants have reached the six to seven leaf stage, extended into the early summer period.

For chicory the yield in the first autumn (Figure 4) is higher than the second autumn (Figure 5), due to a lower plant population after the flowering of the first summer period.

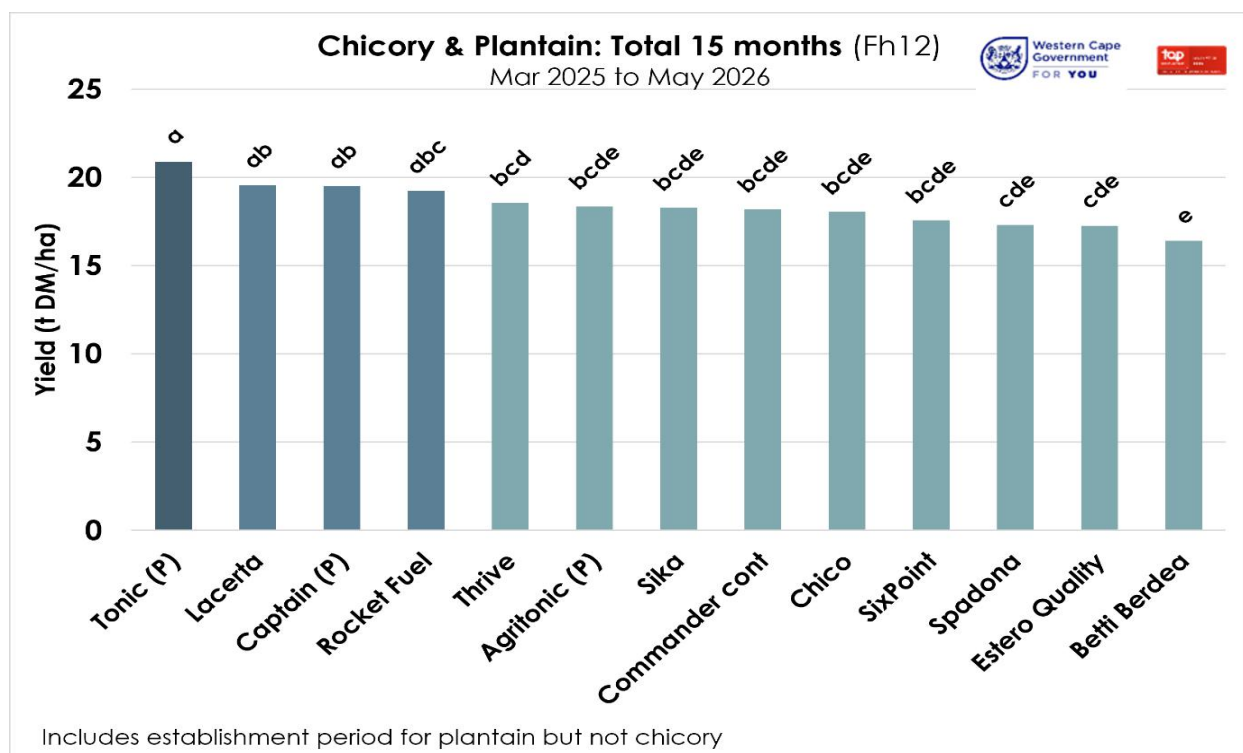


Figure 1. Chicory and plantain dry matter yield total (t DM/ha) for the period March 2025 to May 2026 extending over the 15 months from autumn 2025 to autumn 2026.

Table 1. Seasonal yield of forage herbs chicory and palntain

		Chicory (<i>Cichorium intybus</i>), Plantain (<i>Plantago lanceolata</i>)										Outeniqua Research Farm, Trial Fh12			
		Table 1: Seasonal yield (t DM/ha)										Chicory planted 18 November 2024, Plantain planted 18 February 2025			
Cultivars	Type	Summer 2024/25		Autumn 2025		Winter 2025		Spring 2025		Summer 2025/26		Autumn 2026		Total 15 months Aut 2025 to Aut 2026	
			Rank		Rank		Rank		Rank		Rank		Rank		Rank
Betti Berdea	C	3,34 ^{ab}	4	4,09 ^{abc}	8	1,40 ^{de}	10	5,31 ^{def}	10	3,91 ^e	13	1,71 ^f	12	16,40 ^e	13
Chico	C	3,21 ^b	7	4,42 ^{ab}	3	1,41 ^{de}	9	6,02 ^{bcde}	5	4,13 ^{cde}	11	2,07 ^{cd}	9	18,05 ^{bcde}	9
Commander	C	3,77 ^a	1	4,36 ^{abc}	4	1,48 ^{de}	7	5,67 ^{def}	8	4,46 ^{cde}	7	2,21 ^{bc}	7	18,17 ^{bcde}	8
Estero Quality	C	3,31 ^{ab}	5	4,29 ^{abc}	6	1,37 ^e	12	5,10 ^f	13	4,34 ^{cde}	8	2,18 ^{bc}	8	17,26 ^{cde}	12
Lacerta	C	3,17 ^b	8	4,46 ^a	2	3,10 ^{ab}	3	5,27 ^{def}	11	4,77 ^{bc}	4	1,95 ^{def}	10	19,55 ^{ab}	2
Rocket Fuel	C	3,53 ^{ab}	2	4,51 ^a	1	1,65 ^d	6	6,12 ^{bcd}	4	4,63 ^{bcd}	5	2,30 ^{bc}	6	19,21 ^{abc}	4
Sika	C	3,23 ^{ab}	6	3,92 ^c	10	1,45 ^{de}	8	5,84 ^{cde}	6	4,53 ^{bcde}	6	2,52 ^{bc}	4	18,28 ^{bcde}	7
SixPoint	C	3,09 ^b	10	4,01 ^{bc}	9	1,37 ^{de}	11	5,54 ^{def}	9	4,18 ^{cde}	10	2,48 ^{bc}	5	17,58 ^{bcde}	10
Spadona	C	3,35 ^{ab}	3	4,19 ^{abc}	7	1,36 ^e	13	5,70 ^{def}	7	4,13 ^{cde}	12	1,90 ^{ef}	11	17,29 ^{cde}	11
Thrive	C	3,13 ^b	9	4,32 ^{abc}	5	2,96 ^{bc}	4	5,27 ^{def}	12	4,32 ^{cde}	9	1,67 ^f	13	18,54 ^{bcd}	5
Agritonic	P	-		*1,04		2,71 ^c	5	6,70 ^{abc}	3	5,19 ^b	2	2,70 ^{ab}	3	18,35 ^{bcde}	6
Captain	P	-		*1,30		3,26 ^a	1	7,04 ^a	1	5,17 ^b	3	2,72 ^{ab}	2	19,50 ^{ab}	3
Tonic	P	-		*1,47		3,16 ^{ab}	2	6,86 ^{ab}	2	6,22 ^a	1	3,18 ^a	1	20,90 ^a	1
LSD (0.05)		0,55		0,45		0,29		0,88		0,68		0,57		1,98	
CV%		9,7		7,3		8,5		9,0		8,9		15,3		6,5	
Yields with the same letter are statistically similar within a column C = Chicory, P = Plantain * includes establishment period															
Consider plantain separately due to later planting.															

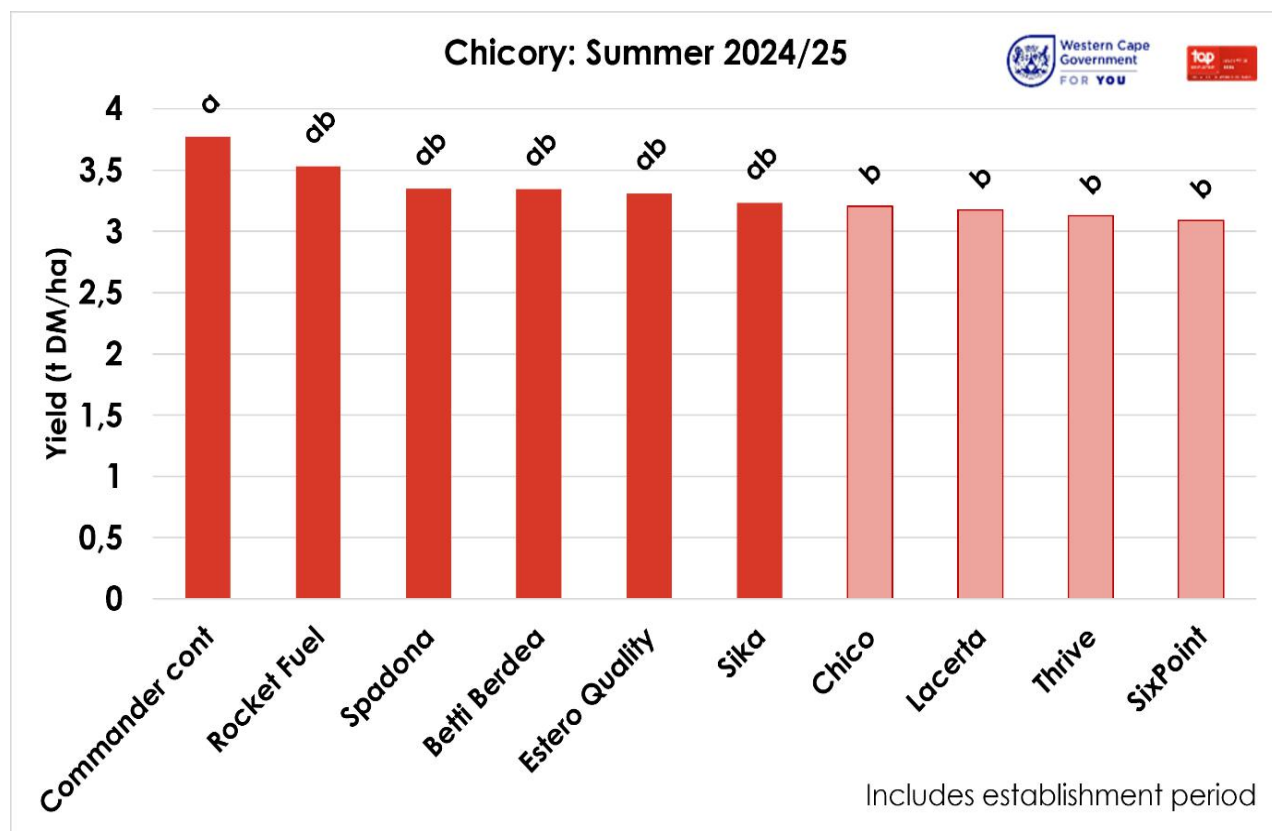


Figure 2. Chicory dry matter yield (t DM/ha) for the first summer 2024/25. The trial was planted in late spring and thus the establishment period extended into the early summer.

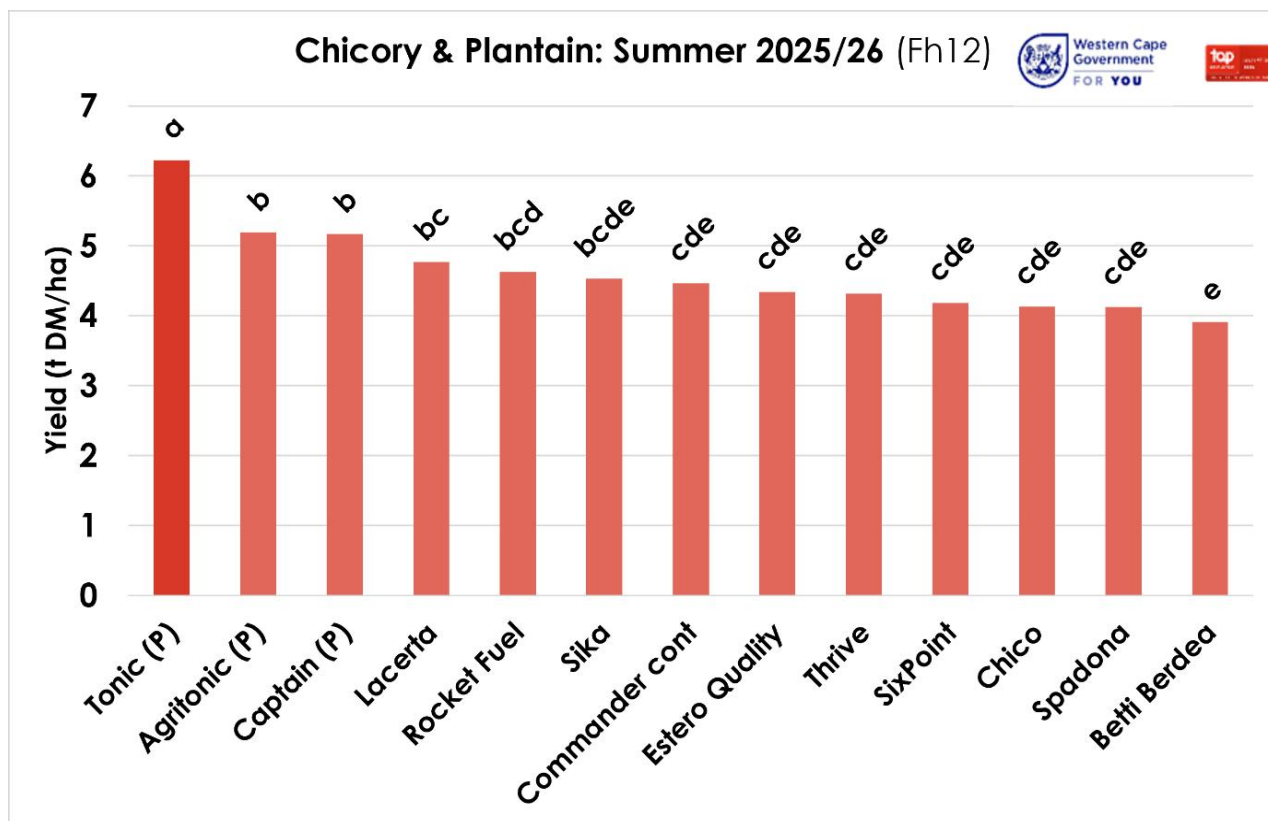


Figure 3. Dry matter yield (t DM/ha) for the second summer December 2025 to February 2026 for chicory and plantain.

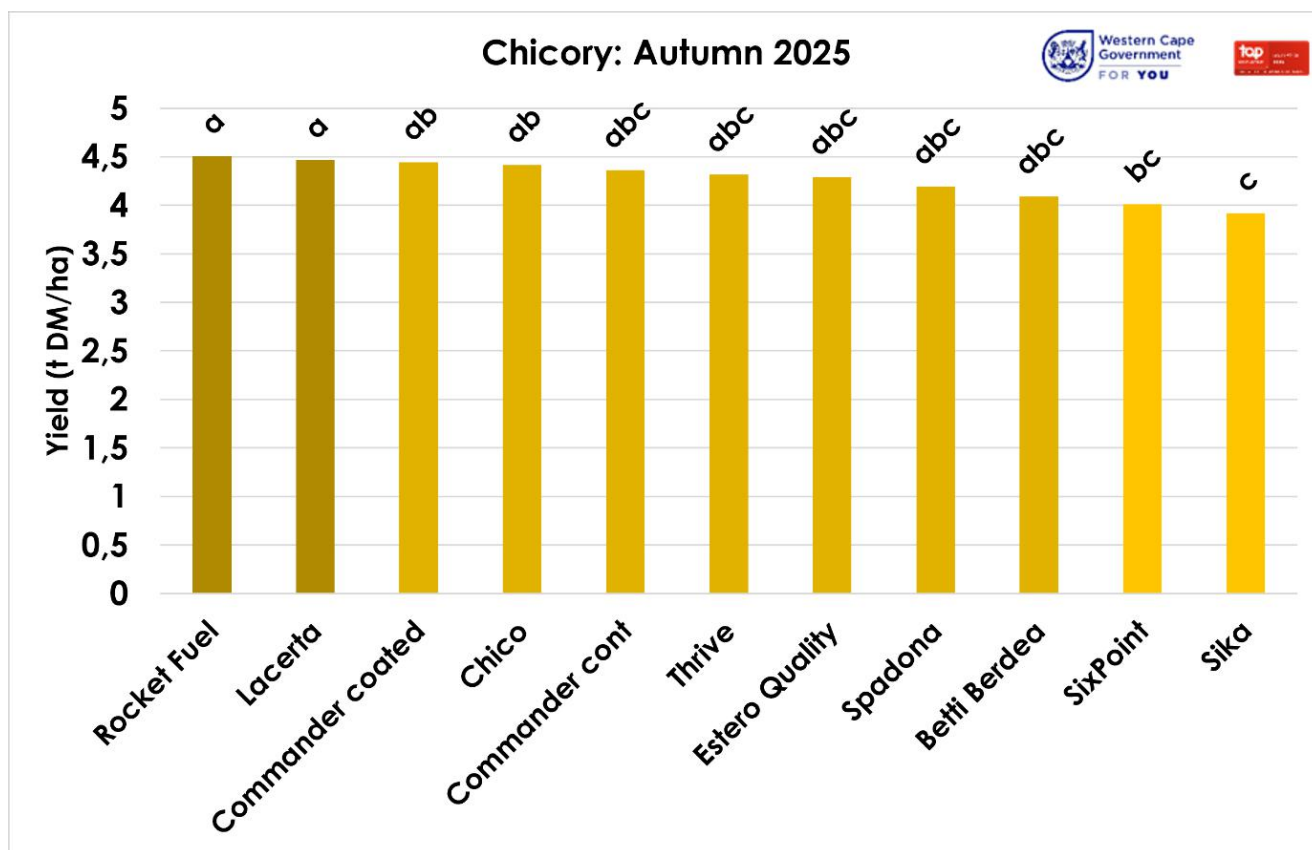


Figure 4. Chicory yield (t DM/ha) for the first autumn March to May 2025.

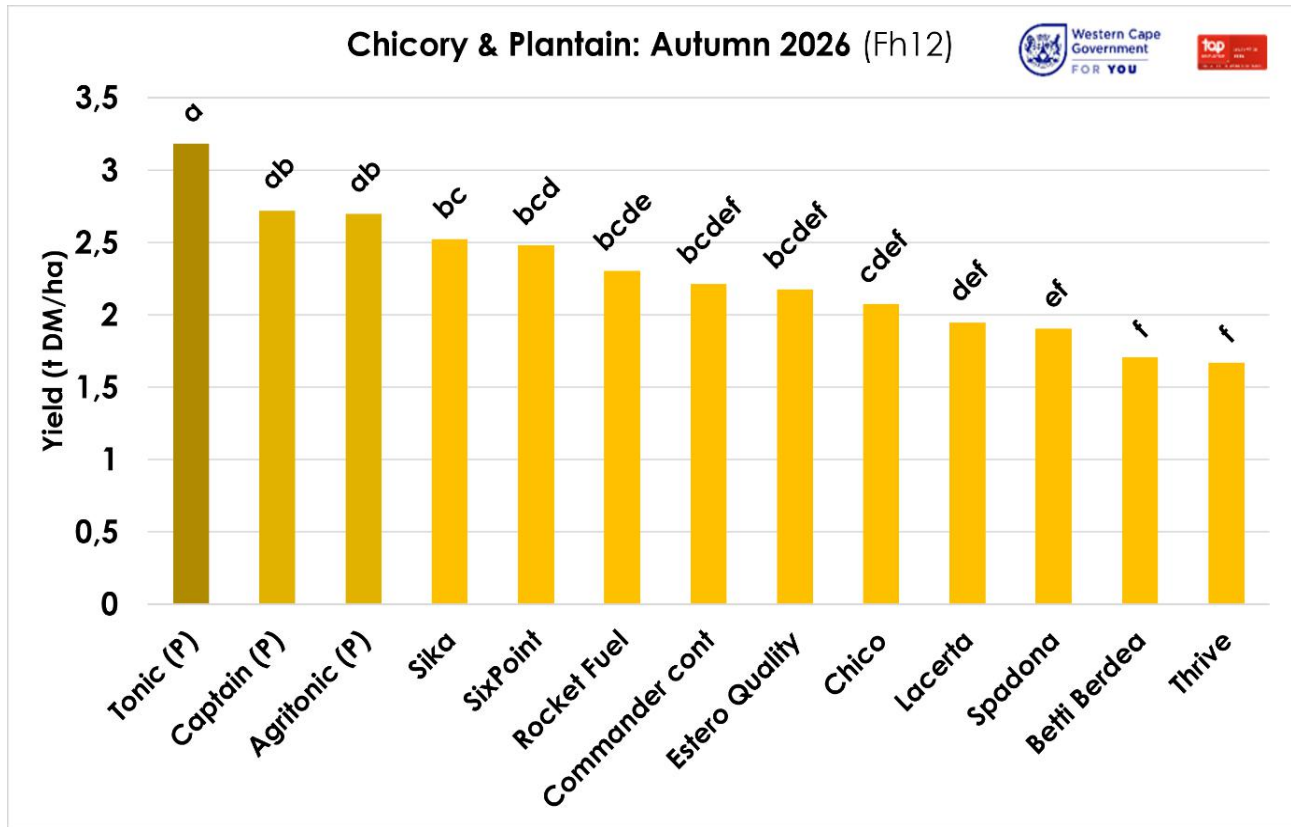


Figure 5. Chicory and plantain yield (t DM/ha) for the second autumn March to May 2026.

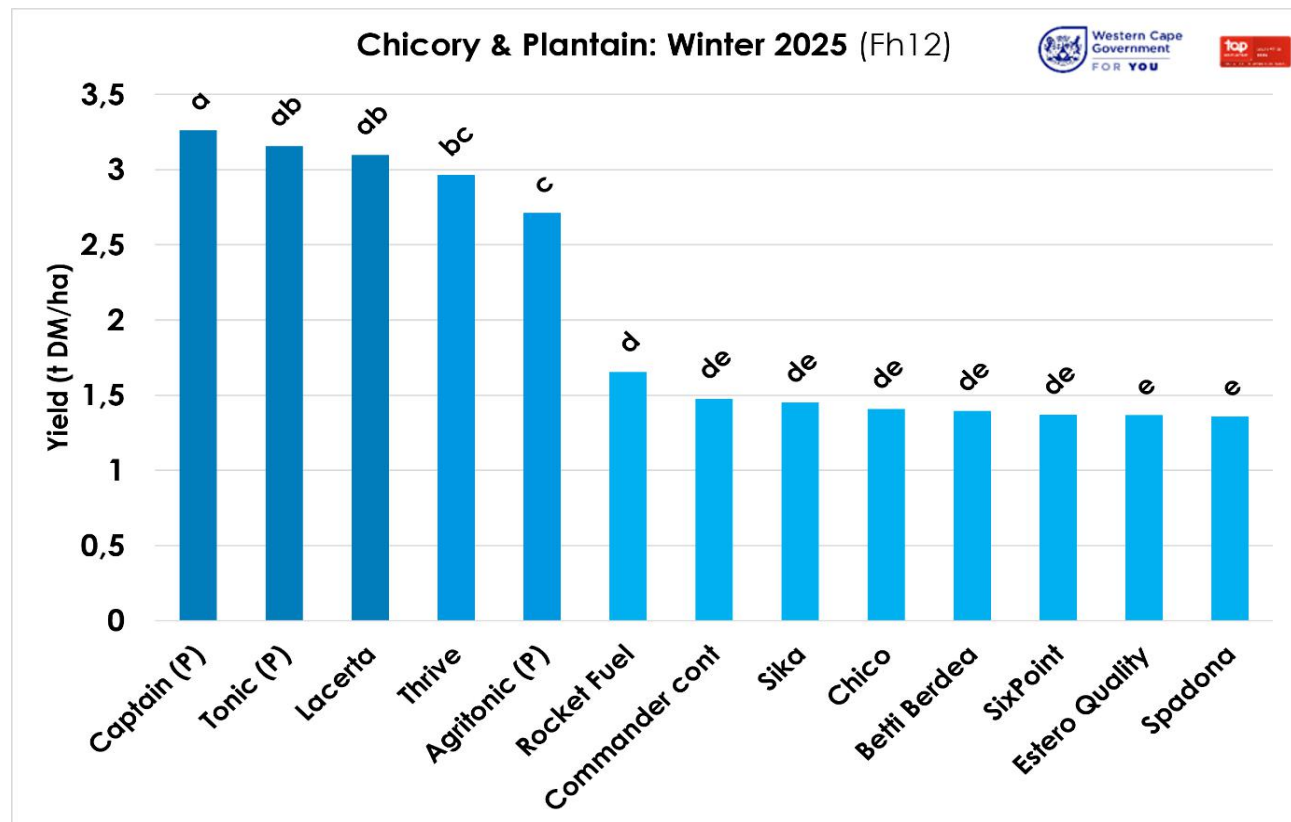


Figure 6. Chicory and plantain winter yield (tDM/ha) for the period June to August 2025.

Growth rates are given in Table 2. These are especially relevant for pure stand pastures. Research done on incorporating pure stands of plantain into the daily grazing allocation is reported in the Outeniqua Information Day 2024 p51-63 with particular focus on the effects on intake.

Flowering incidence (Table 3) is an important aspect of choosing a chicory cultivar, since the chicory flowering stem is not readily grazed by cows. Certain cultivars like Lacerta and Thrive have a good winter yield but a very high flowering incidence in spring and summer.

During the summer months extra samples were taken to determine the leaf to stem weight. This was used to calculate the grazable yield (Table 4) for the spring and summer months, that is the leaf yield assuming the cows would leave the flowering stems standing. Figure 7 shows the leaf and stem yield vs the leaf yield only for January 2026 i.e. the grazable yield. The figure shows Lacerta and Thrive have the best yields in January but a

Chicory (*Cichorium intybus*), Plantain (*Plantago lanceolata*) Outeniqua Research Farm, Trial Fh12

Table 2: Growth rates (kg DM/ha/day) Chicory planted 18 November 2024, Plantain planted 18 February 2025

Cultivars	Type	Summer 2024/25	Rank	Autumn 2025	Rank	Winter 2025	Rank	Spring 2025	Rank	Summer 2025/26	Rank	Autumn 2026	Rank	Total 15 months Aut 2025 to Aut 2026	Rank
Belli Berdea	C	63,1 ^{ab}	4	44,5 ^{abc}	8	15,2 ^{cde}	7	58,3 ^{def}	7	43,37 ^e	10	18,57 ^f	9	16,40 ^e	10
Chico	C	60,5 ^b	7	48,0 ^{ab}	3	15,3 ^{cde}	6	66,2 ^{bcd}	2	45,90 ^{cde}	8	22,50 ^{cdef}	6	18,05 ^{bcde}	6
Commander	C	71,2 ^a	1	47,4 ^{abc}	4	16,0 ^{cde}	4	62,2 ^{def}	5	49,57 ^{cde}	4	24,07 ^{bcd}	4	18,17 ^{bcde}	5
Estero Quality	C	62,5 ^{ab}	5	46,6 ^{abc}	6	14,8 ^e	9	56,0 ^f	10	48,20 ^{cde}	5	23,67 ^{bcd}	5	17,26 ^{cde}	9
Lacerta	C	59,8 ^b	8	48,5 ^a	2	33,7 ^{ab}	1	57,9 ^{def}	8	52,97 ^{bc}	1	21,17 ^{def}	7	19,55 ^{ab}	1
Rocket Fuel	C	66,7 ^{ab}	2	49,1 ^a	1	18,0 ^d	3	67,3 ^{bcd}	1	51,37 ^{bcd}	2	25,07 ^{bcde}	3	19,21 ^{abc}	2
Sika	C	61,0 ^{ab}	6	42,7 ^c	10	15,8 ^{cde}	5	64,2 ^{cdef}	3	50,33 ^{bcde}	3	27,43 ^{bc}	1	18,28 ^{bcde}	4
SixPoint	C	58,3 ^b	10	43,6 ^{bc}	9	14,9 ^{cde}	8	60,8 ^{def}	6	46,47 ^{cde}	7	26,97 ^{bcd}	2	17,58 ^{bcde}	7
Spadona	C	63,3 ^{ab}	3	45,6 ^{abc}	7	14,8 ^e	10	62,7 ^{def}	4	45,83 ^{cde}	9	20,70 ^{ef}	8	17,29 ^{cde}	8
Thrive	C	59,0 ^b	9	46,9 ^{abc}	5	32,2 ^{bc}	2	58,0 ^{def}	9	47,97 ^{cde}	6	18,13 ^f	10	18,54 ^{bcd}	3
Agritonic	P	-		*11,3		29,5 ^c		73,6 ^{abc}		57,73 ^b		29,33 ^{ab}		18,35 ^{bcde}	
Captain	P	-		*14,2		35,5 ^a		77,4 ^a		57,43 ^b		29,57 ^{ab}		19,50 ^{ab}	
Tonic	P	-		*16,0		34,3 ^{ab}		75,4 ^{ab}		69,13 ^a		34,60 ^a		20,90 ^a	
LSD (0.05)		10,35		4,84		3,10		9,74		0,68		0,57		1,98	
CV%		9,7		7,3		8,5		9,1		8,9		15,3		6,5	

Values with the same letter are statistically similar within a column C = Chicory, P = Plantain * includes establishment period
Consider plantain separately due to later planting.

Chicory (*Cichorium intybus*), Plantain (*Plantago lanceolata*) Outeniqua Research Farm, Trial Fh12

Table 3: Flowering % (ratings based) Chicory planted 18 November 2024, Plantain planted 18 February 2025

Cultivars	Type	Cut 2 12 Feb 2025	Cut 3 10 Mar 2025	Cut 4 7 Apr 2025	Cut 5 7 May 2025	Cut 6 12 Jun 2025	Cut 7 14 Aug 2025	Cut 8 18 Sep 2025	Cut 9 21 Oct 2025	Cut 10 13 Nov 2025	Cut 11 4 Dec 2025	Cut 12 5 Jan 2026	Cut 13 16 Feb 2026	Cut 14 19 Mar 2026	Cut 15 15 May 2026	Cut 16 29 Jun 2026	Summary
Belli Berdea	C	0	0	0	0	0	0	0	3	12	54	54	38	5	12	0	...
Chico	C	0	0	0	0	0	0	0	2	17	42	46	29	5	14	0	...
Commander	C	0	0	0	0	0	0	0	3	17	38	63	38	5	10	0	...
Estero Quality	C	0	0	0	0	0	0	0	5	14	46	54	46	5	8	0	...
Lacerta	C	0	0	0	0	0	0	10	46	67	79	92	88	17	38	3	...
Rocket Fuel	C	0	0	0	0	0	0	0	3	8	58	63	38	12	5	0	...
Sika	C	0	0	0	0	0	0	0	5	17	25	29	10	5	5	0	...
SixPoint	C	0	0	0	0	0	0	2	14	25	25	38	21	5	5	0	...
Spadona	C	0	0	0	0	0	0	0	5	10	46	54	46	5	18	0	...
Thrive	C	0	0	0	0	0	0	12	21	38	75	92	88	12	23	2	...
Agritonic	P	0	0	0	0	0	0	5	75	54	75	73	38	0	0	0	...
Captain	P	0	0	0	0	0	0	17	83	54	75	89	25	0	0	0	...
Tonic	P	0	0	0	0	0	0	5	79	58	67	71	21	0	0	0	...
LSD (0.05)								6,3	9,7	18,1	18,30	17,5	24,1	8,10	21,10	2,3	
CV%								105,0	23,2	36,9	20,2	16,7	34,9	82,7	122,4	288	

Values with the same letter are statistically similar within a column C = Chicory, P = Plantain

Table 4. Grazeable yield of plantain and chicory

Chicory (*Cichorium intybus*), Plantain (*Plantago lanceolata*) Outeniqua Research Farm, Trial Fh12

Table 4: Grazeable yield (t DM/ha) leaf component only

Chicory planted 18 November 2024, Plantain planted 18 February 2025

Cultivars	Type	Cut 9 total 21 Oct 2025	Cut 9 leaf only 21 Oct 2025	Cut 10 total 13 Nov 2025	Cut 10 leaf only 13 Nov 2025	Cut 11 total 4 Dec 2025	Cut 11 leaf only 4 Dec 2025	Cut 12 total 5 Jan 2026	Cut 12 leaf only 5 Jan 2026	Cut 13 total 16 Feb 2026	Cut 13 leaf only 16 Feb 2026	Cut 14 total 19 Mar 2026	Cut 14 leaf only 19 Mar 2026	Cut 15 total 15 May 2026	Cut 15 leaf only 15 May 2026
Betti Berdea	C	1,77 ^{de}	1,67 ^{ab}	1,66 ^{abc}	1,44 ^{bc}	1,13 ^{cdef}	0,65 ^c	1,72 ^d	0,93 ^{cde}	1,81 ^d	1,21 ^{bc}	0,94 ^{efg}	0,94 ^{bcd}	0,87 ^e	0,84 ^{bc}
Chico	C	2,25 ^{abcd}	2,20 ^a	1,75 ^{ab}	1,51 ^{abc}	1,27 ^{cd}	0,85 ^{ab}	1,83 ^d	1,10 ^{abc}	1,85 ^{cd}	1,33 ^{bc}	1,17 ^{cde}	1,17 ^{ab}	1,08 ^{cde}	0,96 ^{abc}
Commander	C	1,78 ^{de}	1,67 ^{bc}	1,83 ^{ab}	1,57 ^{ab}	1,27 ^{cd}	0,85 ^{ab}	1,94 ^{cd}	0,97 ^{bcd}	2,04 ^{bcd}	1,43 ^{abc}	1,26 ^{bcd}	1,26 ^{ab}	1,15 ^{bcd}	1,05 ^{abc}
Estero Quality	C	1,71 ^e	1,57 ^{bc}	1,59 ^{bc}	1,39 ^{bc}	1,08 ^{def}	0,63 ^c	1,83 ^d	1,02 ^{bcd}	2,05 ^{bcd}	1,32 ^{bc}	1,19 ^{cde}	1,19 ^{ab}	1,18 ^{bcd}	1,13 ^{abc}
Lacerta	C	1,78 ^{de}	1,08 ^c	1,45 ^{cd}	0,65 ^e	1,00 ^{ef}	0,35 ^d	2,36 ^{abc}	0,66 ^e	2,09 ^{bcd}	0,61 ^e	0,82 ^{ga}	0,68 ^d	1,14 ^{cde}	0,78 ^c
Rocket Fuel	C	1,98 ^{cde}	1,87 ^{ab}	1,90 ^a	1,70 ^a	1,39 ^{bc}	0,75 ^{bc}	2,05 ^{bcd}	1,06 ^{bc}	2,08 ^{bcd}	1,37 ^{abc}	1,26 ^{bcd}	1,21 ^{ab}	1,23 ^{bcd}	1,23 ^{abc}
Sika	C	2,02 ^{bcd}	1,85 ^{ab}	1,77 ^{ab}	1,52 ^{abc}	1,20 ^{cdef}	0,95 ^a	1,94 ^{cd}	1,43 ^a	2,03 ^{bcd}	1,81 ^a	1,45 ^{abc}	1,45 ^a	1,31 ^{bcd}	1,31 ^{ab}
SixPoint	C	1,84 ^{cde}	1,61 ^{bc}	1,74 ^{ab}	1,33 ^c	1,23 ^{cde}	0,95 ^a	1,83 ^d	1,29 ^{ab}	1,93 ^{bcd}	1,58 ^{ab}	1,12 ^{de}	1,12 ^{ab}	1,44 ^{abc}	1,44 ^a
Spadona	C	1,77 ^{de}	1,62 ^{bc}	1,93 ^a	1,69 ^a	1,31 ^{bcd}	0,79 ^{abc}	1,76 ^d	0,96 ^{bcd}	1,96 ^{bcd}	1,22 ^{bc}	1,07 ^{def}	1,07 ^b	0,99 ^{de}	0,9 ^{bc}
Thrive	C	1,88 ^{cde}	1,49 ^{bc}	1,28 ^d	0,90 ^d	0,97 ^f	0,40 ^d	2,10 ^{bcd}	0,69 ^{de}	1,94 ^{bcd}	0,62 ^{de}	0,72 ^g	0,70 ^{cd}	0,96 ^{de}	0,82 ^{bc}
LSD (0.05)		0,53	0,57	0,27	0,23	0,26	0,18	0,5	0,35	0,36	0,45	0,29	0,34	0,38	0,52
CV%		15,8	20,3	9,3	9,9	12,2	14,5	13,8	20,6	10,3	21,5	14,7	18,6	5,4	29,6

Values with the same letter are statistically similar within a column C = Chicory, P = Plantain Sample split for leaf and stem used to calculate leaf only yield

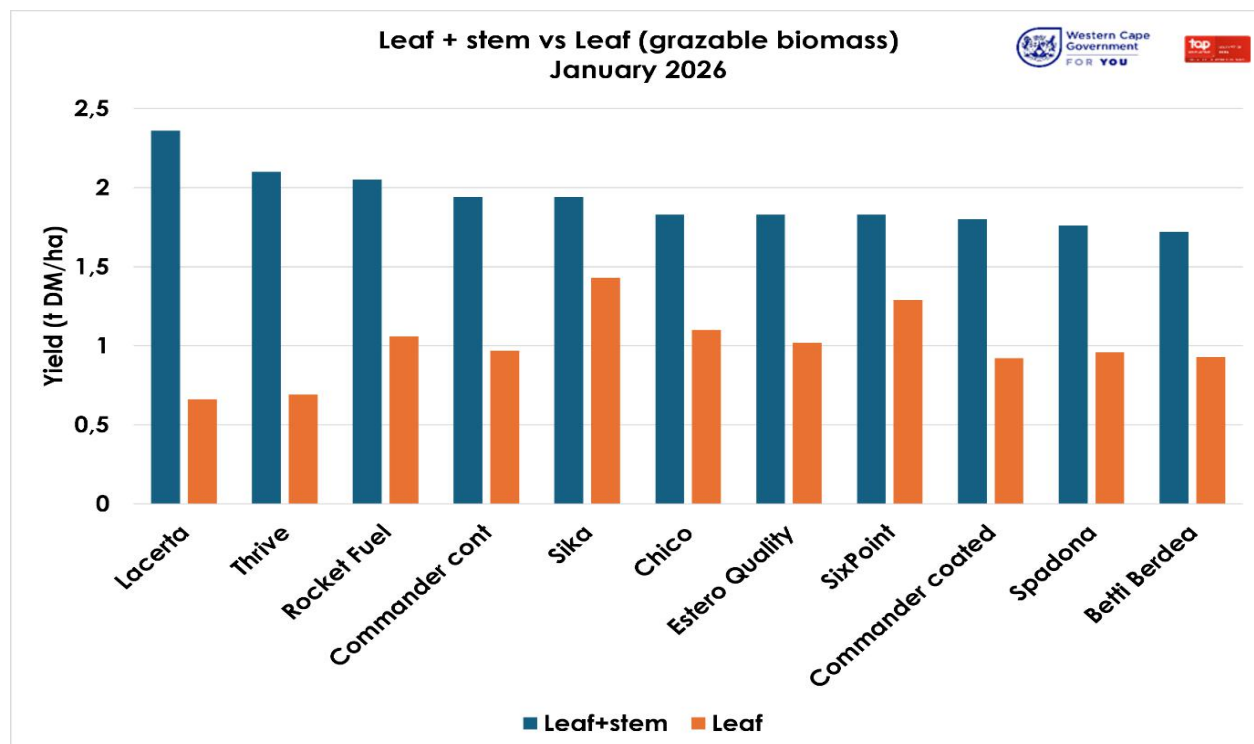


Figure 7. Comparing the biomass of the leaf component to the total biomass of leaf and stem for the January harvest.

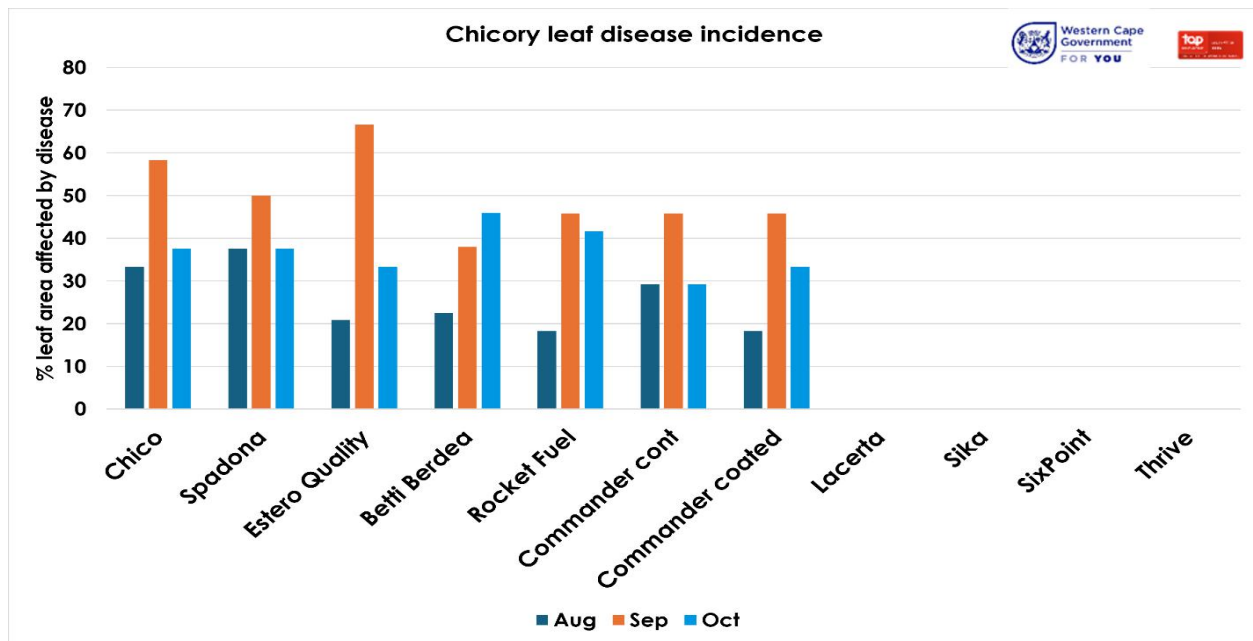


Figure 8. Leaf disease incidence on chicory cultivars for the months August to October 2025.

During the late winter and spring, if conditions are conducive, chicory can become affected by fungal leaf diseases. In this trial leaf disease (Table 5) was quite prevalent in the months August to October and was assessed visually in relation to how much of the leaf area of the plot was affected. Figure 8 shows the **leaf disease incidence** which affected the cultivars Betti Berdea, Chico, Commander, Estero, Rocket Fuel and Spadona. The cultivars Lacerta, Thrive, Sika and Six Point were free of leaf disease.

Plant height (Table 6) was recorded at each harvest. There are differences between cultivars. The data showed the lack of growth during the winter months, when most chicory cultivars only reached a height of between 13 and

15cm. The growth form changed from upright to flat during those months. The only exception are the cultivars Thrive and Lacerta and the three plantain cultivars Agritonic, Captain and Tonic. These height differences are reflected in the yield data.

The sward density (Table 7) is a rating quantifying the density of the stand at harvest. This is related to plant density although the sward density does not decline initially with a reduction in plant density as the remaining plants tend to grow larger when the population is lower. This compensation is up to a point when the gaps in the stand become too large and open spaces develop.

		Chicory (<i>Cichorium intybus</i>), Plantain (<i>Plantago lanceolata</i>)																Outeniqua Research Farm, Trial Fh12	
		Table 5: Leaf disease % (ratings based)																Chicory planted 18 November 2024, Plantain planted 18 February 2025	
Cultivars	Type	Cut 2 12 Feb 2025	Cut 3 10 Mar 2025	Cut 4 7 Apr 2025	Cut 5 7 May 2025	Cut 6 12 Jun 2025	Cut 7 14 Aug 2025	Cut 8 18 Sep 2025	Cut 9 21 Oct 2025	Cut 10 13 Nov 2025	Cut 11 4 Dec 2025	Cut 12 5 Jan 2026	Cut 13 16 Feb 2026	Cut 14 19 Mar 2026	Cut 15 15 May 2026	Cut 16 29 Jun 2026	Summary		
Betti Berdea	C	0	0	0	0	0	23	38	46	0	0	0	0	0	0	0			
Chico	C	0	0	0	0	0	33	58	38	0	0	0	0	0	0	0			
Commander	C	0	0	0	0	0	29	46	29	0	0	0	0	0	0	0			
Estero Quality	C	0	0	0	0	0	21	67	33	0	0	0	0	0	0	0			
Lacerta	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Rocket Fuel	C	0	0	0	0	0	18	46	42	0	0	0	0	0	0	0			
Sika	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
SixPoint	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Spadona	C	0	0	0	0	0	38	50	38	0	0	0	0	0	0	0			
Thrive	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
LSD (0.05)							27,7	20,3	18,9										
CV%							128,5	48,4	60,9										
Values with the same letter are statistically similar within a column																		C = Chicory, P = Plantain	

Chicory (*Cichorium intybus*), Plantain (*Plantago lanceolata*)

Outeniqua Research Farm, Trial Fh12

Table 6: Height (cm)

Chicory planted 18 November 2024, Plantain planted 18 February 2025

Cultivars	Type	Cut 2 12 Feb 2025	Cut 3 10 Mar 2025	Cut 4 7 Apr 2025	Cut 5 7 May 2025	Cut 6 12 Jun 2025	Cut 7 14 Aug 2025	Cut 8 18 Sep 2025	Cut 9 21 Oct 2025	Cut 10 13 Nov 2025	Cut 11 4 Dec 2025	Cut 12 5 Jan 2026	Cut 13 16 Feb 2026	Cut 14 19 Mar 2026	Cut 15 15 May 2026	Cut 16 29 Jun 2026	Summary
Betti Berdea	C	42	42	41	38	36	14	34	37	38	37	36	40	34	28	33	
Chico	C	42	39	44	40	35	14	30	35	38	38	38	40	35	30	30	
Commander	C	45	42	38	40	40	14	32	37	35	32	40	43	39	34	32	
Estero Quality	C	42	43	43	38	38	14	29	37	36	37	40	40	38	34	28	
Lacerta	C	42	40	39	37	40	37	44	35	30	28	32	35	33	33	34	
Rocket Fuel	C	43	43	41	40	38	14	30	38	40	38	38	43	38	31	32	
Sika	C	39	38	38	34	33	13	32	38	37	32	37	40	39	31	28	
SixPoint	C	38	38	34	33	32	12	26	32	30	28	32	38	36	27	34	
Spadona	C	44	39	40	40	38	15	28	35	33	33	37	42	38	32	31	
Thrive	C	40	35	38	38	40	36	44	33	30	27	32	33	28	33	31	
Agritonic	P	-	-	20	22	29	22	29	27	27	29	28	33	28	26	24	
Captain	P	-	-	20	25	35	30	32	28	27	28	31	30	25	24	24	
Tonic	P	-	-	20	22	34	31	35	30	25	28	32	33	28	27	26	
LSD (0.05)		5,1	5,6	3,5	4,3	3,4	4,0	5,6	5,9	6,9	4,7	5,5	6,3	7,1	7,1	6,4	
CV%		7,1	8,1	5,5	7,3	5,6	12,0	10,2	10,4	12,4	8,6	9,4	9,9	12,4	14,2	12,9	

Values with the same letter are statistically similar within a column

C = Chicory, P = Plantain

Chicory (*Cichorium intybus*), Plantain (*Plantago lanceolata*)

Outeniqua Research Farm, Trial Fh12

Table 7: Sward density (ratings based)

Chicory planted 18 November 2024, Plantain planted 18 February 2025

Cultivars	Type	Cut 2 12 Feb 2025	Cut 3 10 Mar 2025	Cut 4 7 Apr 2025	Cut 5 7 May 2025	Cut 6 12 Jun 2025	Cut 7 14 Aug 2025	Cut 8 18 Sep 2025	Cut 9 21 Oct 2025	Cut 10 13 Nov 2025	Cut 11 4 Dec 2025	Cut 12 5 Jan 2026	Cut 13 16 Feb 2026	Cut 14 19 Mar 2026	Cut 15 15 May 2026	Cut 16 29 Jun 2026	Summary
Betti Berdea	C	100	100	100	100	100	96	96	83	100	83	92	92	79	92	86	
Chico	C	100	100	100	100	100	100	100	100	96	100	96	96	88	92	92	
Commander	C	100	100	100	100	100	100	100	100	100	100	96	96	88	96	96	
Estero Quality	C	96	100	100	100	100	96	100	96	92	92	96	96	88	96	90	
Lacerta	C	100	100	100	100	100	100	96	96	96	96	100	92	67	83	94	
Rocket Fuel	C	100	100	100	100	100	96	100	96	100	100	100	100	92	92	88	
Sika	C	100	100	100	100	100	100	100	100	100	100	100	100	100	100	98	
SixPoint	C	92	92	100	96	96	100	92	96	96	96	96	96	96	100	96	
Spadona	C	100	100	100	100	100	96	96	88	83	79	79	79	71	79	75	
Thrive	C	100	100	100	100	100	100	100	100	100	92	100	92	75	83	92	
Agritonic	P	-	-	-	67	63	83	88	83	88	83	96	96	92	92	90	
Captain	P	-	-	-	67	75	92	100	96	92	83	92	96	88	92	94	
Tonic	P	-	-	-	83	88	100	100	96	100	96	100	100	96	100	100	
LSD (0.05)		8,3	7,4	NS	19,0	13,3	11,4	10,8	12,3	16,1	16,8	13,5	15,6	20,2	16,7	18,8	
CV%		4,9	4,4		12,1	8,4	7,0	6,6	7,8	10,1	10,9	8,5	9,9	14,1	10,9	12,3	

Values with the same letter are statistically similar within a column

C = Chicory, P = Plantain

* Includes establishment period
Consider plantain separately due to later planting.

Chicory (*Cichorium intybus*)

Outeniqua Research Farm, Trial Fh12

Table 8: Plant population (plants/m²)

Chicory planted 18 November 2024

Cultivars	Type	Plant population plants/m ² Counted 4 Dec 2025 (1 year old)
Betti Berdea	C	68 ^b
Chico	C	76 ^{ab}
Commander	C	84 ^{ab}
Estero Quality	C	74 ^{ab}
Lacerta	C	80 ^{ab}
Rocket Fuel	C	90 ^a
Sika	C	80 ^{ab}
SixPoint	C	67 ^b
Spadona	C	73 ^{ab}
Thrive	C	90 ^a
LSD (0.05)		20,3
CV%		14,0

Values with the same letter are statistically similar within a column C = Chicory

Note: The seed of all the above varieties was uncoated.
If coated seed is planted the seeding rate must be increased to achieve the same seed mass sown as uncoated.

Plant population counts for chicory (Table 8) were done in December 2025 when the chicory plants were 1 year old. Most varieties still had a significantly high population above what is considered the cut-off where it would affect yield negatively. According to Dairy NZ a minimum of 30 plants/m² is required for an acceptable yield potential (<https://www.dairynz.co.nz/feed/crops/chicory>). The sward density ratings corresponded with the plants counts. Counts will again be done in the second summer.

Chicory (*Cichorium intybus*), Plantain (*Plantago lanceolata*)

Outeniqua Research Farm, Trial Fh12

Table 9: Forage quality (Nov 2025)
NIRS, Dairyland

Chicory planted 18 November 2024,
Plantain planted 18 February 2025

Cultivars	Type	CP %	Rank	NDF %	Rank	ADF %	Rank	WSC %	Rank	NFC %	Rank
Betti Berdea	C	21,5 ^a	10	34,8 ^b	10	26,9 ^{bc}	10	10,6 ^{ab}	2	34,9 ^a	3
Chico	C	22,2 ^a	5	34,4 ^b	13	26,5 ^c	13	10,4 ^{ab}	6	35,0 ^a	2
Commander	C	21,6 ^a	9	35,6 ^b	7	27,2 ^{bc}	8	10,4 ^{ab}	5	34,5 ^a	4
Estero Quality	C	23,2 ^a	1	34,9 ^b	9	26,9 ^{bc}	9	9,4 ^b	10	33,1 ^a	11
Lacerta	C	22,0 ^a	6	35,0 ^b	8	27,6 ^{bc}	6	10,4 ^{ab}	4	33,7 ^a	10
Rocket Fuel	C	22,3 ^a	4	34,7 ^b	11	26,9 ^{bc}	11	10,5 ^{ab}	3	34,4 ^a	7
Sika	C	21,6 ^a	8	35,7 ^b	6	27,7 ^{bc}	5	10,3 ^{ab}	7	34,0 ^a	9
SixPoint	C	22,6 ^a	2	36,0 ^b	5	27,5 ^{bc}	7	9,6 ^{ab}	9	32,5 ^a	13
Spadona	C	21,7 ^a	7	34,4 ^b	12	26,8 ^{bc}	12	11,3 ^a	1	34,5 ^a	5
Thrive	C	22,5 ^a	3	36,1 ^b	4	28,0 ^b	4	8,7 ^b	13	32,6 ^a	12
Agritonic	P	17,6 ^b	11	41,1 ^a	2	30,0 ^a	3	9,0 ^b	12	35,1 ^a	1
Captain	P	17,0 ^b	13	41,1 ^a	3	30,4 ^a	2	10,0 ^{ab}	8	34,5 ^a	6
Tonic	P	17,0 ^b	12	41,7 ^a	1	30,6 ^a	1	9,1 ^b	11	34,0 ^a	8
LSD (0.05)		1,97		2,45		1,30		1,87		2,68	
CV%		5,60		4,0		2,8		11,1		4,7	

Values with the same letter are statistically similar within a co C = Chicory, P = Plantain

Chicory (*Cichorium intybus*), Plantain (*Plantago lanceolata*)

Outeniqua Research Farm, Trial Fh12

Table 10: DM%

Chicory planted 18 November 2024, Plantain planted 18 February 2025

Cultivars	Type	Sum 2024/25 Feb	Rank	Autumn 2025 Apr	Rank	Winter 2025 Aug	Rank	Spring 2025 Oct	Rank	Sum 2025/26 Jan	Rank	Autumn 2026 May	Rank
Betti Berdea	C	11,9 ^{ab}	4	7,6 ^b	7	14,0 ^{ab}	2	11,2 ^{bc}	5	12,8 ^{ef}	9	10,9 ^{bcd}	10
Chico	C	12,5 ^a	1	7,6 ^b	8	13,6 ^{ab}	5	13,5 ^a	3	13,6 ^{cdef}	6	11,0 ^{bc}	8
Commander	C	11,0 ^{ab}	7	7,5 ^b	10	13,5 ^{abc}	7	10,2 ^c	10	12,6 ^{ef}	10	11,0 ^{bc}	9
Estero Quality	C	10,9 ^{ab}	8	7,6 ^b	9	13,6 ^{abc}	6	10,3 ^{bc}	8	13,3 ^{def}	7	11,3 ^{bc}	5
Lacerta	C	11,8 ^{ab}	5	7,1 ^b	12	9,8 ^e	12	9,9 ^c	11	15,3 ^{bc}	3	11,2 ^{bc}	6
Rocket Fuel	C	12,1 ^a	3	7,6 ^b	6	13,4 ^{abc}	8	10,4 ^{bc}	6	12,1 ^f	11	11,1 ^{bc}	7
Sika	C	11,2 ^{ab}	6	7,1 ^b	13	13,8 ^{ab}	3	9,3 ^c	14	11,7 ^f	13	9,9 ^d	13
SixPoint	C	9,9 ^b	10	7,9 ^b	4	14,8 ^a	1	10,4 ^{bc}	7	11,7 ^f	12	10,3 ^{cd}	12
Spadona	C	10,7 ^{ab}	9	7,7 ^b	5	13,7 ^{ab}	4	10,2 ^c	9	13,3 ^{def}	8	11,3 ^{bc}	4
Thrive	C	12,2 ^a	2	7,4 ^b	11	9,6 ^e	13	9,7 ^c	12	14,0 ^{cde}	4	10,4 ^{cd}	11
Agritonic	P	-		13,7 ^a	1	12,4 ^{bcd}	9	13,8 ^a	1	18,1 ^a	1	14,0 ^a	2
Captain	P	-		12,8 ^a	3	11,8 ^{cd}	10	13,5 ^a	2	17,2 ^{ab}	2	14,1 ^a	1
Tonic	P	-		13,4 ^a	2	11,4 ^{de}	11	12,5 ^{ab}	4	14,8 ^{cd}	4	13,8 ^a	3
LSD (0.05)		1,99		1,56		1,80		2,24		1,93		1,05	
CV%		10,1		10,6		8,4		12,0		8,3		5,39	

Values with the same letter are statistically similar within a column C = Chicory, P = Plantain

Forage quality parameters were determined on cut 10 which was in November 2025 i.e in late spring when chicory is an important part of the pasture components on a farm. The results are shown in Table 9. The CP% clearly shows the difference between chicory and plantain, with plantain having a lower CP%. This makes it a useful component with ryegrass and red clover. Ryegrass often

has a higher than required CP%. The red clover quality also compliments that of the plantain in terms of CP. For the chicory the CP% ranged between 21 and 23%. Chicory had a lower NDF% than plantain. The average NDF% for the chicory cultivars was 35.2% while that for plantain was 41.3%. Both are within the acceptable range for dairy pastures.

The carbohydrate parameters Water Soluble carbohydrates (WSC) and Non-Fibre Carbohydrates (NFC) were similar for chicory and plantain. Both parameters represent the highly digestible sugars and starches. WSC consists of simple sugars and fructans while NFC additionally includes starches, organic acids and pectins (Villalba et al 2021). Balancing the ratio of energy to protein results in ore efficient use of the forage in terms of digestion and reducing nitrogen losses (Dalley et al. 2017)

Summary

- **Best producing chicory varieties based on 15 months yield and based on grazable yield during the flowering period:** Rocket Fuel, Sika followed by Chico, and SixPoint, Commander.
- **Best plantain over 15 months:** Tonic and Captain.
- **Winter production:** Plantain significantly higher than chicory. Chicory cultivars Lacerta and Thrive have good winter production but a very high flowering percentage during summer.

- **Fungal leaf disease resistance:** SixPoint, Sika, Lacerta, Thrive
- **Lowest flowering incidence:** Sika, SixPoint, Chico

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EFFECT OF DIATOMS ON MILK PRODUCTION

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Introduction

Diatomaceous earth is a naturally occurring substance made up of fossilised diatoms, a type of algae found in freshwater and marine environments as shown in Figure 1. Diatoms have hard shells consisting mainly of non-crystalline silica, which accumulate over time as deposits in dried-up lakes and other sedimentary environments. Their highly porous structure gives diatomaceous earth the potential to bind substances such as mycotoxins, pesticides and toxic metals. It is also a source of soluble silicon (Fernandez et al. 1998).

Research on the benefits of diatomaceous earth in livestock has produced mixed results. Fernandez et al. (1998) found no improvement in growth performance or reduction in internal parasites when diatomaceous earth was supplemented to beef steers. In contrast, Gorlov et al. (2020) reported improved milk production and composition in dairy cows supplemented with a mineral complex containing 63.8% diatomite. However, the complex also contained other ingredients, making it difficult to attribute the improvements to diatom alone.

Voerdokter, a diatomaceous earth concentrate (DAEC), is a registered feed additive for ruminants and monogastric animals (Reg no V20435 Act 36 of 1947) as shown in Figure 2. It is produced from high-grade diatom deposits mined near Olifantshoek in the Northern Cape, South Africa. The recommended inclusion rate for dairy cows is 100 to 125 g/cow/day, with potential benefits including improved animal health and reduced parasite burdens.

However, feed additives increase feeding costs, and their benefits must justify the additional expense. Limited research is available on the effect of diatomaceous earth on milk production and composition in pasture-based dairy systems. In response to interest from farmers and feed manufacturers, a controlled study was conducted to evaluate the effects of supplementing Voerdokter to Jersey cows grazing ryegrass pasture during spring.

Aim: To determine whether supplementation with diatomaceous earth concentrate affects milk production and milk composition in pasture-fed Jersey cows during spring.

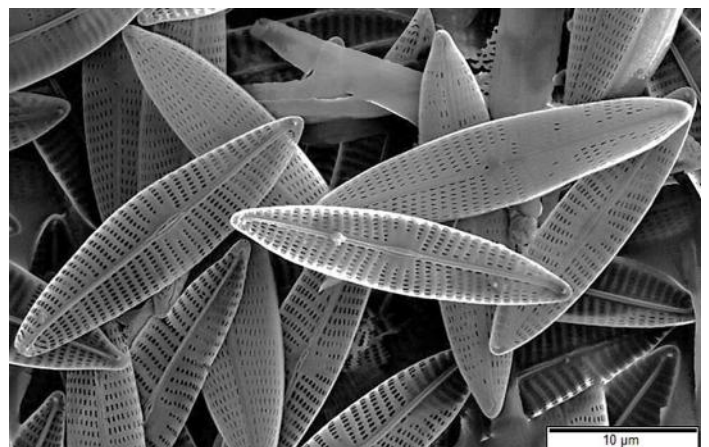


Figure 1. Scanning electron microscopic image of marine Diatoms (image credit: Mogana Das Murtey and Patchamuthu Ramasamy, CC-BY SA3.0, Wikimedia)

Table 1. Ingredient and nutrient composition of concentrates (% of DM).

Ingredient	Control	*Low Voerdokter 75g/cow/day	**High Voerdokter 150g/cow/day
Maize	54.0	54.0	54.0
Hominy chop	15.0	15.0	15.0
Wheat bran	12.55	11.65	10.70
Soybean oilcake	10.0	10.0	10.0
Molasses	4.0	4.0	4.0
Feed lime	2.90	2.35	1.85
Salt	0.5	0.5	0.5
MgO	0.2	0.2	0.2
Ureum	0.4	0.45	0.5
DAEC (Voerdokter)*	0	1.4	2.8
Premix	0.446	0.446	0.446
Nutrient composition			
DM (%)	87.6	87.7	87.8
CP (%)	15.1	15.1	15.1
ME (MJ/kg)	12.6	12.5	12.4
Ca (%)	1.24	1.22	1.21
P (%)	0.48	0.47	0.46
Mg (%)	0.42	0.41	0.40

*Low Voerdokter inclusion 1.25% on as is basis (6 kg concentrate/cow/day: 75 g Voerdokter/cow/day)

** High Voerdokter inclusion 2.5% on as is basis (6 kg concentrate/cow/day: 150 g Voerdokter/cow/day)

Materials and methods

The study was conducted from September to November 2024 at the Outeniqua Research Farm near George in the Western Cape, South Africa. Sixty Jersey cows grazing irrigated kikuyu/ryegrass pasture were used in a randomised block design to evaluate the effect of diatomaceous earth concentrate (DAEC; Voerdokter) on milk production and composition.

Cows were grouped according to milk production, lactation number and days in milk before being randomly allocated to one of three treatments. Following a 14-day preliminary adaptation period, cows received their respective treatments for 21 days before a 56-day measurement period.

Treatments:

1. Control: 6 kg dairy concentrate/cow/day without Voerdokter
2. Low inclusion: 6 kg dairy concentrate/cow/day containing 75 g Voerdokter/cow/day (1.25%).
3. High inclusion: 6 kg dairy concentrate/cow/day containing 150 g Voerdokter/cow/day (2.5%).

All cows grazed together on irrigated kikuyu/ryegrass pasture, with fresh pasture allocated after each milking.



Figure 2. Voerdokter product

Pasture was managed on a 21–25-day grazing cycle, with approximately 6–7 kg dry matter (DM) allocated per cow per grazing. Each cow received 3 kg of its assigned concentrate during both morning and afternoon milking. The ingredient and nutrient composition of the concentrate is presented in Table 1.

Milk production was recorded daily, while milk samples were collected every second week during the measurement period and analysed for fat, protein, lactose, milk urea nitrogen (MUN) and somatic cell count (SCC). Pasture and concentrate samples were collected regularly

Table 2. Composition of concentrates and pasture on DM basis.

	Control	DAEC low	DAEC high	Pasture
DM% ave	88,6 ± 0,35	88,7 ± 0,28	88,6 ± 0,34	12,6 ± 1,91
As%	7,72 ± 0,326	8,11 ± 0,230	8,27 ± 0,151	13,9 ± 1,85
Crude Protein %	13,9 ± 0,61	13,9 ± 0,18	14,0 ± 0,17	21,5 ± 5,14
Crude Fibre %	3,84 ± 0,427	3,28 ± 0,147	3,01 ± 0,541	24,6 ± 2,01
Neutral detergent fibre %	14,0 ± 3,08	13,3 ± 2,83	15,0 ± 1,14	45,4 ± 3,61
Acid detergent fibre %	5,23 ± 0,331	5,40 ± 0,242	5,56 ± 0,453	28,3 ± 2,45
In Vitro organic matter digestibility %	93,8 ± 1,07	94,9 ± 0,69	95,9 ± 0,99	91,3 ± 4,03

to determine their nutrient composition.

Body weight and body condition score (BCS) were recorded at the beginning and end of the study. Body condition was assessed on a scale of 1 (thin) to 5 (fat) according to Wildman et al (1982).

Statistical analyses

Data were analysed as a randomised block design using analysis of variance (ANOVA) with the General Linear Models Procedure (PROC GLM) of SAS version 9.4 (SAS Institute Inc, Cary, USA). Treatment and lactation group were evaluated as fixed effects, with block included in the model. Additional analyses were performed within lactation groups and to assess treatment x lactation interaction.

The assumptions of normality and homogeneity of variance were assessed using the Shapiro-Wilk test (Shapiro and Wilk, 1965) and Levene's test (Levene, 1960), respectively. Treatment means were compared using least-squares means (LSMeans), with statistical significance assessed at $P < 0.05$.

Results and discussion

The effects of diatomaceous earth concentrate (DAEC) supplementation on milk production, milk composition, body condition score and live weight are presented in Table 3. Statistical significance was assessed at $P < 0.05$.

Supplementation with DAEC had no significant effect on milk production or 4% fat-corrected milk production (FCM). Milk fat and protein percentages were relatively high across all treatments, with no significant differences between treatments. Similarly, DAEC supplementation had no significant effect on milk lactose, somatic cell count (SCC) or milk urea nitrogen (MUN). Although SCC was numerically lower in both DAEC treatments than in the control, these differences were not statistically significant. Body condition score and live weight gain were also not significantly affected by DAEC supplementation. Cows receiving DAEC showed numerically higher live weight

gains than control cows, but these differences were not statistically significant ($P = 0.16$).

The absence of significant treatment effects is consistent with findings from other studies. Fernandez et al. (1998) reported no improvement in growth performance when diatomaceous earth was supplemented to beef steers. More recently, EFSA (2025) reported that diatomaceous earth supplementation did not significantly affect milk production or most milk composition parameters in dairy cows. The good quality pasture and similar feeding conditions across treatments in the present study may have contributed to the limited differences observed. However, the results do not establish why DAEC had no significant effect, and responses under different feeding conditions or supplementation levels cannot be excluded. The average rising plate meter (RPM) reading was 25.5 ± 5.49 before grazing and 9.6 ± 1.19 after grazing. Cows received an average pasture allocation of 14.5 kg DM/cow/day.

The nutrient composition of the concentrates and pasture is presented in Table 2. Pasture contained 12.6% dry matter, 21.5% crude protein and 45.4% neutral detergent fibre (NDF), indicating good-quality pasture during the study. Cows were also grouped according to lactation number (fewer than five lactations and five or more lactations) to determine whether responses differed between younger and older cows. Final live weight differed significantly between lactation groups ($P = 0.0047$), but this difference was not associated with DAEC supplementation. A significant treatment x lactation group interaction was observed for final body condition score ($P = 0.045$), indicating that the response to DAEC supplementation differed between lactation groups for this parameter. However, no significant treatment x lactation group interactions were observed for milk production or milk composition.

Table 3. Parameters with measurements for treatments plus p-value, standard error and contrasts between treatments.

PARAMETER	Control	*DAEC Low	DAEC High	StdErr	p-value	1 vs 2	1 vs 3	2 vs 3
	Treatment 1	Treatment 2	Treatment 3					
Milk production (kg/cow/day)	19,1	18,9	19,0	0,22	0,78	0,49	0,79	0,67
**4% FCM (kg/cow/day)	22,4	22,7	22,1	0,38	0,52	0,58	0,56	0,26
Milk production month 1 (kg/cow/day)	20,0	19,8	20,1	0,22	0,68	0,60	0,73	0,39
Milk production month 2 (kg/cow/day)	18,2	18,0	18,0	0,24	0,68	0,43	0,47	0,94
Butterfat %	5,18	5,37	5,10	0,12	0,28	0,27	0,64	0,12
Protein %	4,02	3,95	3,92	0,05	0,40	0,38	0,19	0,66
Lactose %	4,57	4,52	4,50	0,02	0,06	0,12	0,02	0,44
Somatic cell count (x1000)	298	147	177	70,26	0,29	0,14	0,23	0,77
MUN (mg/dl)	11,8	11,5	12,1	0,40	0,52	0,51	0,64	0,26
Body condition score beginning	2,26	2,26	2,25	0,01	0,62	1,00	0,40	0,40
Body condition score end	2,32	2,29	2,29	0,02	0,58	0,37	0,37	1,00
Body condition score gain	0,06	0,03	0,04	0,02	0,62	0,33	0,63	0,63
Live weight start (kg/cow)	410	416	413	8,11	0,86	0,59	0,75	0,82
Live weight end (kg/cow)	411	424	421	7,51	0,45	0,23	0,35	0,78
Live weight gain (kg/cow)	1,36	8,08	7,67	2,72	0,16	0,09	0,11	0,91

* DAEC – (Diatomaceous earth)

** FCM - Fat corrected milk

Conclusion

Supplementation with diatomaceous earth concentrate (DAEC; Voerdokter) did not significantly affect milk production, milk composition, somatic cell counts (SCC), milk urea nitrogen (MUN), body condition score or live weight gain in Jersey cows grazing kikuyu/ryegrass pasture during spring. Although cows receiving DAEC had numerically lower SCC and higher live weight gains, these differences were not statistically significant.

Previous studies have reported varying responses to diatomaceous earth supplementation, but no significant overall production benefits were observed under the conditions of this study. The treatment period lasted approximately two months, and it is possible that a longer supplementation period could produce different results. However, further research would be needed to determine whether longer-term supplementation provides any benefits.

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NUTRIENT LOSSES FROM PASTORAL SYSTEMS - TOWARDS MORE EFFICIENT, SUSTAINABLE AND RESILIENT DAIRY PRODUCTION

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Introduction

Pasture-based dairy production is an important component of agriculture in the Western Cape, South Africa (Gertenbach 2007). These systems rely on the efficient conversion of pasture into milk, with pasture productivity, forage quality, animal nutrition and milk yield traditionally forming the foundation of dairy research (MPO 2017). Improving these components remains essential for profitable and sustainable dairy farming. However, increasing production alone does not necessarily mean that the production system is becoming more efficient.

Dairy farms operate within a complex biological system in which nutrients move continuously between the soil, pasture, animals and the wider environment. Nutrients are introduced through fertilisers, biological nitrogen fixation (BNF) and purchased feeds. Some are removed in milk and animal products, while others are returned to the soil through dung, urine and plant residues. During these processes, nutrients may also be lost to the atmosphere or surrounding water resources (Smit et al. 2020; Smit et al. 2021).

Nitrogen (N) is particularly important because it is essential for pasture growth and milk production, but it is also associated with several environmental concerns. Nitrogen losses can occur through nitrous oxide (N_2O) emissions (Smit et al. 2020), ammonia (NH_3) volatilization and nitrate (NO_3^-) leaching (Smit et al. 2021). In addition, enteric methane (CH_4) emissions from dairy cows contribute to the overall greenhouse gas emissions of the production system (van Wyngaard et al. 2018).

Understanding these nutrient pathways is becoming increasingly important as the dairy industry seeks to maintain productivity while responding to environmental pressures, rising input costs and the need for long-term resilience.

From pasture production to whole-system efficiency

Historically, pasture-based dairy research has focussed strongly on increasing forage production and improving its nutritional value. Research has examined fertiliser application, pasture species, grazing management, forage quality, animal nutrition and milk production. These are all important areas because the availability of high-quality pasture is central to the success of a grazing dairy system. Nitrogen fertilisation is one of the main management tools used to improve pasture growth. Adequate nitrogen availability supports plant development, increases forage production and can contribute to greater milk production per hectare. However, pasture responses to additional nitrogen are not unlimited.

Once N enters the system, it moves through several interconnected components. Pasture plants take up N from the soil and incorporate it into plant material. Grazing animals consume this forage and use a portion of the N for maintenance, growth and milk production. However, not all the N consumed by a dairy cow is converted into milk or animal tissue. A substantial proportion is returned to the pasture through urine and dung.

These excreta represent an important source of nutrient cycling, but they can also create areas of high N

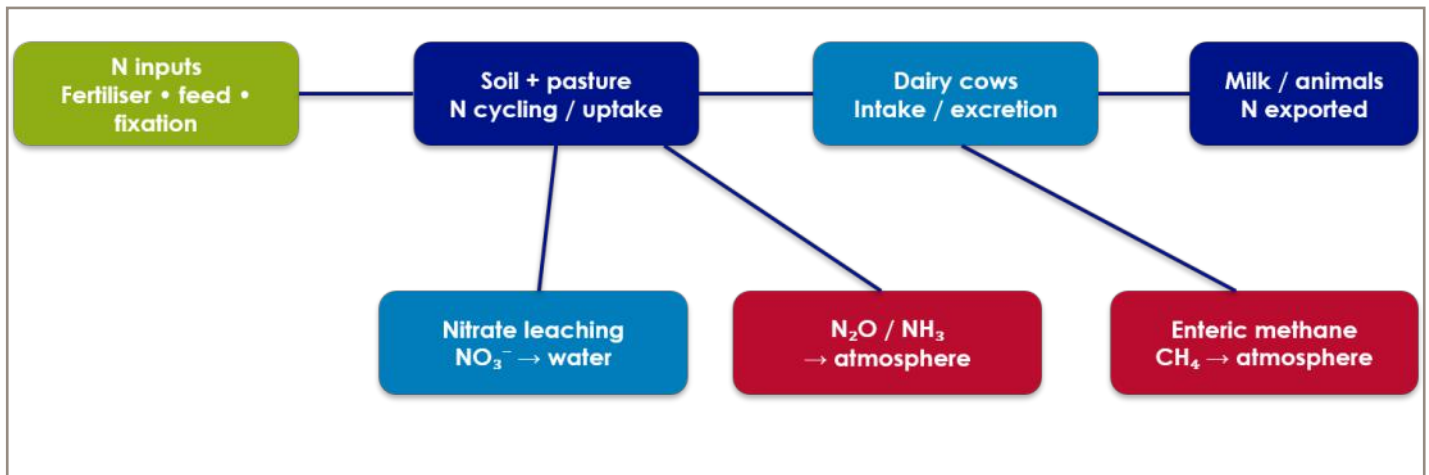


Figure 1. Simplified overview of nutrient flows in a pasture-based dairy production system, showing nitrogen inputs, nutrient cycling, nitrogen exported through milk and animals, and potential environmental losses through nitrate leaching, gaseous nitrogen emissions and enteric methane.

concentration within the pasture. The fate of this N depends on soil conditions, weather, pasture uptake and management practices.

Figure 1 provides a simplified overview of nutrient flows in a pasture-based dairy system, illustrating nitrogen inputs, nutrient cycling between soil, pasture and animals, nutrient exports through milk and animals, and potential environmental losses. These include nitrate leaching and gaseous N emissions, while enteric CH₄ represents an additional GHG emission associated with dairy production.

The central challenge is therefore not simply to increase the amount of N entering the system, but to improve how efficiently that N is used.

Nitrogen balances: understanding the surplus

A nitrogen balance provides a useful starting point for understanding N-use efficiency. It compares the N entering a defined system with the N removed through agricultural products or other measured outputs.

In pasture-based research, N inputs may include fertiliser N and other sources, while N removal can be represented by the N contained in harvested or grazed pasture. At the whole-farm level, the balance becomes more complex and may include purchased feed, livestock, milk and other nutrient transfers.

A positive N balance indicates that more N has entered the system than has been removed through the outputs included in the calculation. This surplus may contribute to changes in soil N reserves or increase the potential for environmental losses.

Importantly, a N surplus does not mean that the entire

surplus has been lost to the environment. Rather, it indicates N that has not been accounted for in the measured outputs. Additional measurements are needed to determine whether this N remains in the soil, is recycled within the system or is lost through particular pathways.

Nitrogen balance calculations are therefore useful indicators of system efficiency, but they are most informative when combined with measurements of pasture production, soil processes and environmental losses. Research examining different N fertilisation levels has demonstrated the importance of considering both pasture responses and N balances. Increasing N inputs can improve pasture N yield, but the production response does not necessarily increase in direct proportion to the amount of N applied. As N inputs rise, the N surplus may also increase.

This raises an important question requires an integrated assessment of productivity and environmental performance rather than considering pasture yield alone. Answering this question requires an integrated assessment of productivity and environmental performance rather than considering pasture yield alone.

Nitrous oxide emissions from pasture soils

One of the environmental pathways receiving increasing research attention is the emission of nitrous oxide (N₂O) from agricultural soils.

Nitrous oxide is a greenhouse gas (GHG) produced through microbial processes involved in the transformation of N in soil (Stevens et al. 1997). Its production is influenced by several factors, including soil moisture, oxygen availability, temperature and the availability of N.

In grazed dairy pastures, N fertilisation and the deposition

of urine and dung can influence these processes. Urine patches are particularly relevant because they can create localised areas with high concentrations of readily available N.

Nitrous oxide emissions are not constant throughout the year. They can vary substantially over time, especially following fertilisation, grazing events and changes in soil moisture. Consequently, measurements taken on only a few occasions may not adequately represent emissions over an extended period.

Static chambers provide a practical method for measuring N_2O emissions under field conditions. A chamber is placed over a defined area of soil, and gas samples are collected over a specified period. Changes in the concentration of N_2O within the chamber headspace are used to estimate the rate of gas emission from the soil surface. The chambers shown in Figure 2 represent the equipment used to investigate these emissions in pasture systems.



Figure 2. Static chambers used to measure nitrous oxide (N_2O) emissions from the soil under field conditions in a pasture-based dairy production system.

Research on N fertilisation and N_2O emissions illustrates why environmental measurements need to accompany production measurements. Higher N inputs may support pasture growth, but they can also increase the availability of N for microbial processes that generate N_2O (Smit et al. 2020).

The aim is therefore to identify fertilisation and pasture management practices that support productive pastures while limiting unnecessary N losses.

Nitrate leaching: Nitrogen moving below the root zone

Another important pathway for N loss is nitrate leaching. Nitrate (NO_3^-) is a mobile form of N in soil. When nitrate is present in the soil and water moves downward beyond the effective rooting zone, nitrate can be transported with that water. This represents a potential loss of N from the agricultural system and may contribute to water quality concerns.

The risk of nitrate leaching depends on the amount of nitrate available, the ability of plants to take it up, soil properties and the movement of water through the soil. Seasonal conditions are particularly important. Periods of substantial rainfall and drainage can increase the movement of nitrate through the soil profile, especially when pasture N uptake is limited.

Nitrate leaching can be investigated using ceramic suction cups installed below the main rooting zone. These devices allow soil water to be collected under suction and subsequently analysed for nitrate concentration. The suction cup equipment shown in Figure 3 represents this approach to measuring N movement through the soil.



Figure 3. Ceramic suction-cup equipment used to collect soil water for measuring nitrate leaching under pasture conditions.

Research comparing pasture systems and management practices has shown that nitrate leaching is influenced by more than fertilisation alone (Smit et al. 2020). Pasture composition, grazing management, crop rotations and the timing of N availability relative to plant uptake can all affect the amount of nitrate remaining in the soil.

This is particularly relevant in ley-arable systems, where periods of pasture production may be followed by cultivation or other crops. Changes in plant cover and N mineralisation can influence the risk of N losses during transitions between production phases.

Understanding these interactions creates opportunities to improve N retention through better synchronisation of N supply and plant demand.

Methane emissions and the wider environmental perspective

Nitrogen losses represent only one part of the environmental footprint of dairy production.

Enteric methane (CH_4) is produced during microbial fermentation in the digestive system of ruminant animals. It is released primarily through eructation and represents another important GHG associated with dairy production. While N_2O emissions and nitrate leaching are closely linked to N cycling in soils, enteric CH_4 is associated with feed digestion and animal metabolism.

Methods such as the GreenFeed system can be used to investigate CH₄ emissions from individual animals. These measurements provide opportunities to examine relationships between feed characteristics, animal performance and CH₄ production.

Forage quality and pasture composition may influence how efficiently animals convert consumed feed into milk. Consequently, research into feed utilisation and CH₄ emissions forms part of the broader effort to improve the environmental efficiency of dairy production (van Wyngaard et al. 2018).

An important consideration is that reducing one form of environmental loss should not be assessed in isolation. Management changes may affect pasture production, N cycling, animal performance and GHG emissions in different ways.

A whole-system approach is therefore needed to understand the overall consequences of management decisions.

Opportunities through pasture composition and management

Pasture species and mixtures offer opportunities to improve nutrient-use efficiency and the resilience of dairy production systems.

Legumes such as red clover can contribute N to a pasture system through BNF. This may reduce reliance on extremely applied N fertilisers, although the N fixed by legumes must still be managed within the overall nutrient cycle.

Plantain and other forage herbs are also receiving attention as components of more diverse pasture mixtures. Their potential contribution to pasture productivity, seasonal growth, forage quality and N cycling warrants further investigation under local production conditions.

The inclusion of different pasture species may influence the timing and distribution of pasture growth, nutrient uptake and the quality of forage available to grazing animals.

However, the benefits of diverse pastures cannot be assumed to be the same under all conditions. Their performance depends on the species selected, establishment success, persistence, grazing management, soil characteristics and climate.

Research is therefore needed to evaluate these mixtures not only in terms of forage yield, but also in relation to N-use efficiency, environmental losses and animal production.

The overall objective is to develop pasture systems that use available nutrients effectively, maintain productive forage supply and remain resilient under variable environmental

conditions.

Looking beyond pasture yield

Another important aspect of system efficiency is the difference between pasture produced and pasture actually consumed.

Pasture yield measurements provide valuable information about the productive potential of a sward. However, not all available pasture is necessarily utilised by grazing animals. Some forages remain as post-grazing residual material, while other losses may occur through trampling, rejection, harvesting or storage.

Improving pasture utilisation can increase the amount of useful animal feed obtained from the resources already invested in pasture production.

This connects directly with research into forage quality, digestibility and fermentation characteristics. Laboratory techniques, including in vitro gas production methods, can help investigate aspects of feed fermentation and provide supporting information about forage characteristics. Rather than evaluating individual components separately, the aim is to understand how they interact and where improvements can be achieved across the entire dairy production system.

Towards more efficient, sustainable and resilient dairy production

The future of pasture-based dairy research lies in integrating production and environmental objectives. Pasture yield, forage quality and milk production will remain essential measures of success. However, they increasingly need to be considered alongside nutrient-use efficiency, N balances, GHG emissions and nutrient losses to soil water.

This broader approach is particularly important as dairy producers face the combined challenges of input costs, climate variability, environmental expectations and the need to remain economically competitive. Improving efficiency does not necessarily mean reducing production. In many cases, it means obtaining more useful output from the resources already available while avoiding unnecessary losses.

Research into fertilisation strategies, pasture composition, N cycling, nitrate leaching, N₂O emissions, CH₄ production and forage utilisation can provide the scientific basis for better management decisions.

The central message is that pasture-based dairy production should be evaluated as an interconnected system. Soil, pasture and animals cannot be considered independently when assessing nutrient efficiency and environmental performance.

By understanding where nutrients enter the system, how they are used, where they are recycled and where they may be lost, research can help identify practical opportunities for improvement.

Ultimately, the goal is to support dairy production systems that are productive, resource-efficient, environmentally responsible and resilient, ensuring that pasture-based dairying remains viable for future generations.

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